Racing the Rising Tide: Preparing for Sea Level Rise Along Georgia's Coast

Governmental Responses to Sea Level Rise in Glynn County, Georgia

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Introduction

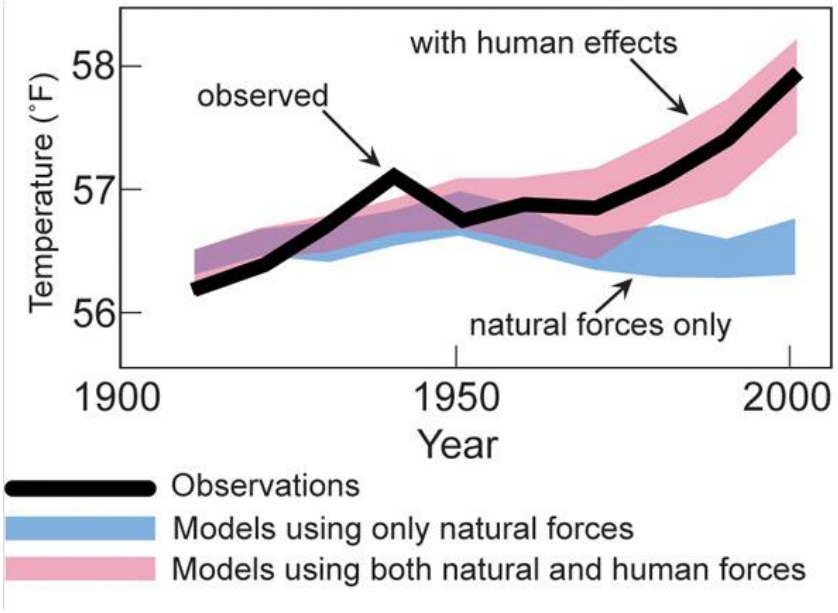
This paper explores sea level rise's impact on Georgia's coast, in terms of both the built and natural environments. Global warming will continue to raise sea levels around the world as the atmosphere warms and glaciers melt at an increasingly alarming pace. Sea level rise has far-reaching impacts on the environment, economy and social cohesion of a community. Fiscally, governments may be forced to spend substantial sums of money on emergency response, insurance payouts, and rebuilding flooded infrastructure. Economic activities may be disrupted and communities torn apart. These are just a few of the problems associated with sea level rise, and are a few of the problems sought to be addressed by coastal hazard planning. Specifically, some issues raised in this paper include: (1) How should governments prepare for sea level rise and coastal flooding at the federal, state and local levels?; (2) Are the land use control tools sought to be employed by local governments legally defensible and economically feasible for a government?; (3) Which tools may be most effective in adapting to sea level rise along Georgia's coast?

This paper establishes a flexible framework by which communities can evaluate the effectiveness and appropriateness of different approaches for creating resilient coastal areas. The effectiveness and appropriateness of a particular approach is determined based on many factors, such as current land use (undeveloped, developed-residential, developed-industrial, etc.), proposed future use, and the estimated economic value of property. This information is especially important in areas that are already heavily developed and urbanized since relocating or retrofitting buildings will be expensive and challenged under a variety of legal theories. Overall, this paper is meant to help state and local decision makers in Georgia identify potential risks and vulnerabilities associated with sea level rise, and assess the range of adaptive strategies that can increase the resilience of urban coastal areas. It is intended to be used as a resource by a wide range of audiences, including government officials, planners, designers, neighborhoods, and communities. The paper provides information useful for many different types of projects that seek to enhance coastal climate resilience at various scales—from site-specific projects to neighborhood, county, or multi-jurisdictional level-plans. Glynn County, Georgia is used to map and analyze the impacts of sea level rise along Georgia's coast, and the range of governmental "tools" available to prepare coastal Georgia for rising seas. Glynn County, Georgia was selected as a test case because many of its developed and undeveloped areas will be affected by sea level rise by 2110.

Literature Review: Climate Change

Climate change is an internationally important and controversial issue. Scientists agree that Earth is warming and that this warming is due in large part to anthropogenic causes. In its most recent report on climate change, the Intergovernmental Panel on Climate Change ("IPCC") concluded, "It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century" (IPCC 2013, 2). "Global atmospheric concentrations of GHGs, including carbon dioxide, methane, and nitrous oxide, have increased markedly as a result of human activities since 1750…" (IPCC Summary for Policymakers, 2007, 2). Although some climate variability is natural, natural forces alone cannot explain the global warming experienced in the second half of the 20th century (Jancaitis 2008). Figure 1 graphically summarizes the results of several climate change models and the account of global warming that can explained by natural forces alone, and then with human effects.

Figure 1: Global Warming, Human Effects and Natural Forces



Source: USGRP 2009

It is important to note that this paper does not include an in-depth discussion on the debate among scientists and policymakers regarding the role humans play in contributing to climate change and sea level rise (SLR). Though scientists may disagree to some extent on the causes of climate change, it is clear that the Earth is warming, and that it is warming at an increasingly worrisome pace. Since the 1950s, the Earth's surface temperature has been increasing by approximately 0.1° Celsius per decade (Houghton et al. 2001). Earth's continued

warming will have significant impacts on populations and ecosystems around the world, and will challenge the viability of our current consumptive patterns and practices.

The Greenhouse Effect

Carbon dioxide (CO_2) is one of the primary greenhouse gases and contributors to climate change, and global warming specifically (EPA 2001).[1] Carbon dioxide is called a "greenhouse" gas because of the warming effect it has on the planet, similar to that of a greenhouse. Greenhouse gases, such as carbon dioxide, threaten to alter Earth's atmosphere since the planet's ecosystems cannot absorb such elevated levels of these gases (EPA 2001). The accumulation of greenhouse gases in the atmosphere admits solar radiation but blocks heat from escaping outside the atmosphere (EPA 2001; Nolan 2013). This chemical process is known as the greenhouse effect, which causes the planet to warm and weather conditions to change (Nolan 2013; EPA 2001). James Titus, an expert in climate change and SLR, described the "greenhouse effect" in a 1988 Environmental Protection Agency report:

> "A planet's temperature is determined primarily by the amount of sunlight it receives, the amount of sunlight it reflects, and the extent to which its atmosphere retains heat. When sunlight strikes the earth, it warms the surface, which then reradiates the heat as infrared radiation. However, water vapor, CO_2, and other gases in the atmosphere absorb some of the radiation rather than allowing it to pass undeterred through the atmosphere to space. Because the atmosphere traps heat and warms the earth in a manner somewhat analogous to the glass panels of a greenhouse, this phenomenon is generally known as the 'greenhouse effect'" (Titus, 1988, 2).

The amount of CO2 in the atmosphere has increased from a pre-industrial rate of 280 parts per million (ppm) to 393 ppm today (Nolon 2013; EPA 2013), though recent evidence suggests that certain developed countries, including the United States, have started to see reductions in carbon emissions after 2010. (EPA 2013). Scientists have concluded that "350 ppm is the tipping point beyond which climate change becomes particularly dangerous to society, especially with regard to sea-level rise caused by the warming of the seas and the melting of polar ice caps, arctic ice, glaciers, and formerly permanent mountain snow caps" (Nolon 2013, 523). Carbon dioxide in the atmosphere has increased by 30% since 1750 (Houghton et al. 2001). Fossil fuel burning has accounted for 75% of the "anthropogenic emissions of carbon dioxide to the atmosphere" in the past two decades, while land use changes, such as

[1] However, Hansen et al. (2000) argue that CO_2 is less of a contributor to climate change relative to non-CO_2 gases such as chlorofluorocarbons , aerosols, N_20 and CH_4.

deforestation, has accounted for the remaining 25% of anthropogenic carbon emissions (Houghton et al. 2001).

The Earth's gradual warming will continue to affect weather patterns, intensify hurricanes and tropical storms, and increase global mean sea levels (Nolan 2013). Global warming will increase the average intensity of the storms while the total number of storms will fall, meaning fewer but more severe cyclones (Emanuel 2005). Furthermore, climate change is also predicted to increase the variability in the amount of precipitation over most areas, and continue to raise Earth's average surface temperature (Houghton et al. 2001), oceans, lower atmosphere, and ice-covered regions (National Research Council 2010).

Sea Level Rise

Global warming will continue to raise sea levels around the world as the atmosphere warms and glaciers melt at an increasingly alarming pace. The most important cause of SLR has been climate change, through global warming, though other factors such as the shifting size and shape of ocean basins have also affected sea level (Titus 1988). Global warming raises sea level by expanding ocean water, melting glaciers, and thawing ice sheets in Greenland and Antarctica that then slide into the oceans (Titus 1988). Most of the projected SLR in the future will be due to thermal expansion and ice melt (IPCC 2013). Ocean thermal expansion and glacier melt have been the dominant contributors to twentieth century global mean SLR (IPCC 2013; Guercio 2013). Polar glaciers in Greenland and Antarctica contain enough water to raise sea level more than seventy (70) meters (Titus 1988). Additionally, some scientists have also argued that anthropogenic processes that affect the "amount of water stored in the ground or on its surface in lakes and reservoirs, or cause changes in land-surface characteristics that influence runoff or evapotranspiration rates" disrupt the hydrological cycle and contribute to sea level rise (IPCC Summary for Policymakers 2013, 13-8).

Oceans are increasingly storing more heat (IPCC 2013), which leads to warmer oceans and higher sea levels. The IPCC recently concluded that ice melt is "very likely" to continue, and that the rate of ice melt has substantially increased since 1970s (IPCC 2013). Specifically, the IPCC's 2013 assessment found that "[s]ince the early 1970s, glacier mass loss and thermal expansion from warming together explain about 75% of the global mean [sea level rise] (IPCC 2013)". Even the U.S. Supreme Court has weighed in on the climate change issue, stating that climate change, and specifically climate change-driven SLR, may have to be calculated into future laws. In *Massachusetts v. EPA*, 549 U.S. 497, 521 (2007), the Court stated:

> "the harms associated with climate change are serious and well recognized. Indeed, the [National Research Council] Report itself—which EPA regards as an objective and

> independent assessment of the relevant science, identifies a number of environmental changes that have already inflicted significant harms, including the global retreat of mountain glaciers, reduction in snow-cover extent, the earlier spring melting of ice on rivers and lakes, [and] the accelerated rate of rise of sea levels during the 20th century relative to the past few thousand years."

In 2013, the IPCC issued its Fifth Assessment regarding climate change and concluded that it is "virtually certain" that the rate of global mean SLR has accelerated during the last two centuries, marking the transition from relatively low rates of change during the late Holocene[2] (order tenths of mm/yr.) to modern rates. According to the IPCC report, it is "virtually certain" that sea levels around the world will continue to rise as the planet continues to warm, and it is "very likely" that there will be a significant increase in the occurrence of future SLR extremes by 2050 and 2100 (IPCC 2013). Depending on the model used, SLR scientists predict global mean sea levels will rise an average of 10-90 centimeters over the next one hundred years. Global mean SLR refers to the increase in all Earth's oceans, which is primarily attributed to changes in two factors: ice melt and thermal expansion. The global average change in mean sea level is a "useful single value which reflects the contribution of climatic processes—land-ice melting and ocean warming, and represents a good estimate of sea level change at many coastal locations" (IPCC Summary for Policymakers 2013, 13-14).

Though global sea level estimates are useful to the extent that they provide a "useful single value which reflects the contribution of climatic processes" across the world (IPCC Summary for Policymakers, 2013, 13-14), "sea level change will have a strong regional pattern, with some places experiencing significant deviations of local and regional sea level change from the global mean change" (IPCC Summary for Policymakers 2013, 13-5). These differences are primarily caused by differences in ocean current, ocean density, salinity and temperature (Church et al., 2010; IPCC 2013). Moreover, "variations in the distribution of land ice affect the shape and gravitational field of the Earth, which also cause regional fluctuations in sea level" (IPCC Summary for Policymakers 2013, 13-13). Regional measures can substantially differ from global average values (IPCC 5th Assessment, 2013), which is why both global estimates and regional estimates along the Atlantic Coast of the United States are included below.

[2] The Holocene era extends from 11,500 BP to the present day (Hansen et al. 2000).

Changes in Global Mean Sea Level Rise

Discrepancies between SLR models arise because of different data sets and methodologies employed in the particular study. The IPCC's 2013 assessment estimates global sea levels to rise approximately 0.58 meters by 2100 (IPCC 2013), though the IPCC's model does not take into consideration ice melt and therefore is considered a relatively conservative model (Guercio 2013). The Climate Change Science Program (2009, 20) has noted that "thoughtful precaution suggests that a sea-level rise of 1 [meter] to the year 2100 should be considered for future planning and policy discussions." Church and White (2006) extended their global mean SLR model back to 1870 using tide gauge data and satellite imaging and found that mean sea level rose from January 1870 to December of 2004 by 195 mm, which averages to a 20th century rate of sea level rise of 1.7 ± .3 mm per year. If this acceleration remains constant, the 1990 to 2100 rise would range from 280 to 340 mm, consistent with projections by early IPCC studies (Church & White 2006).

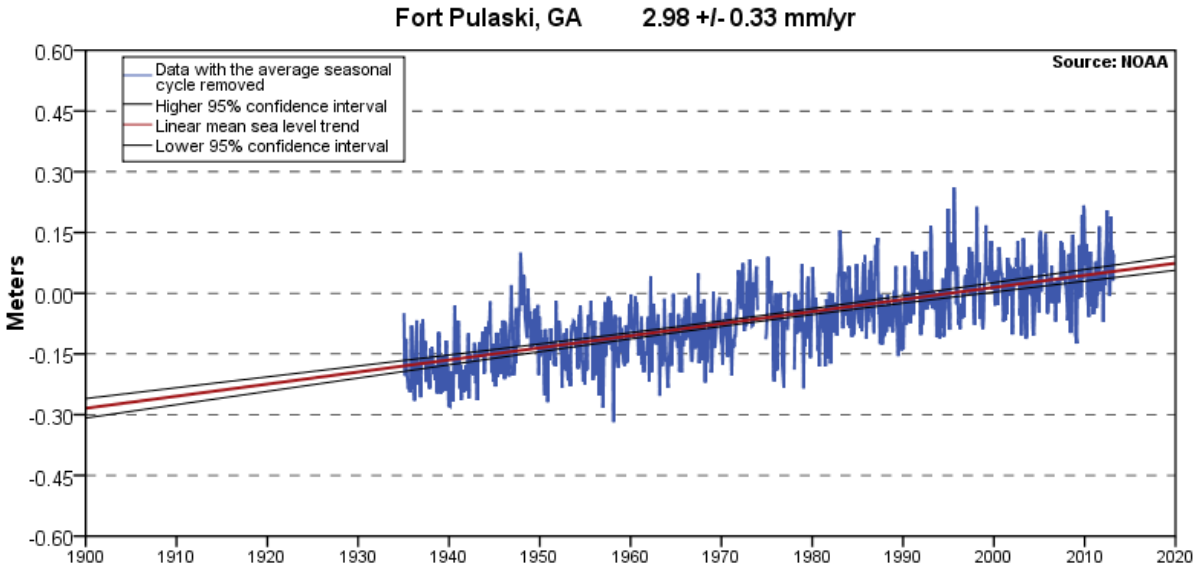
SLR along coasts has been greater than global averages since global averages include rises in the open ocean and along coasts (Holgate & Woodworth 2004). SLR over the last 55 years in coastal areas is estimated to have been 3.7 ± 0.2 millimeters per year, based upon 177 tide gauges divided into 13 regions with calculated weighted averages (Holgate & Woodworth 2004). Holgate and Woodworth used an area-weighted methodology under the assumption that SLR along coasts is greater than SLR in the open ocean. Because the global mean sea level rise data usually include two data sets, open ocean and coastal waters, many models may be too conservative (skewed in favor of sea rise in the open ocean since this is a larger data set). The Holgate and Woodworth (2004) study concluded that sea level "rose faster at the coast than the global ocean averaged over the last decade, at a time when sea level was itself rising faster than at almost any time during the past half century."

Relative Sea Level Rise along the Atlantic Coast and Georgia Coast

Sea level change will have a strong regional pattern, with some places experiencing significant deviations of local and regional sea level change from the global mean change (IPCC 2013). Therefore, relative SLR is normally used to predict the rate of SLR at a particular location. Relative SLR reflects changes in local sea level over time, and is "typically the most critical sea level trend for many coastal applications, including coastal mapping, marine boundary delineation, coastal zone management, coastal engineering, sustainable habitat restoration design, and the general public enjoying their favorite beach" (NOAA n.d., 1). Along the Atlantic Coast of the United States, sea level has risen approximately 30 centimeters (0.3 meters) over

the past 100 years, while tidal gauges across the world have indicated a four to six-inch (0.10-0.15 meters) rise in sea levels over the last decade (Titus et al. 1988). In Georgia specifically, Fort Pulaski near Tybee Island on Georgia's coast has been measuring SLR since the mid-1930s. As shown below in Figure 2, the mean sea level trend in Georgia has been 2.98 millimeters/year with a 95% confidence interval of +/- 0.33 mm/yr based on monthly mean sea level data from 1935 to 2006 (NOAA 2013), though the rate of SLR is likely to increase over the next century (Dorminey 2011). According to scientist Dr. Clark Alexander with the Skidaway Institute of Oceanography, the "second half of this century will likely bring even more accelerated rates of sea level rise" to coastal Georgia (Dorminey 2011). Overall, coastal Georgia's annual 2.98 millimeter rise in sea level is fairly consistent with global mean SLR of 3.1 millimeters/year, while both rates are increasing at a disconcertingly fast rate.

Figure 2: Historical Sea Level Rise Trends at Fort Pulaski, Georgia



Source: NOAA

SLR and Its Impact on Coastal Communities

Coastal areas will be directly impacted by climate change and consequent SLR. Approximately "70% of the global coastlines are projected to experience a sea level change within 20% of global mean sea level change" (IPCC Summary for Policymakers 2013, 13-5). Coastal communities are experiencing significant growth in terms of population and development. Rising sea levels will threaten these coastal communities in a variety of ways, including increased permanent flooding, enhanced storm surge, aquifer depletion and wetland loss. Relative SLR in many of these coastal communities, especially along the Atlantic East Coast, will likely exceed global mean SLR estimates in the next century.

Permanent Inundation

A rise in sea level may threaten populations, property and infrastructure in low-lying coastal zones since even a slight increase in water levels could permanently inundate areas at or near existing sea level. The term "permanent inundation" typically denotes areas where water will permanently cover normally dry lands. Thus, areas located within the projected range of sea level should prepare for normally dry lands to be permanently submerged by encroaching seas. Major river deltas, coastal wetlands and islands would be most affected as these areas are usually at or below sea level (Gornitz 1991).

Increased Storm Surge and Episodic Flooding

In addition to permanent inundation from rising seas, climate change and SLR will also increase storm surge and wave heights on the coast. Areas permanently inundated by rising seas differ from areas that will experience "episodic inundation" from increased storm surge events. Storm surge is an abnormally high series of waves caused by the low pressure and wind in a hurricane which, according to the National Oceanic and Atmospheric Administration (NOAA), constitute the biggest single threat in hurricanes. Episodic flooding by storm waves and surges will penetrate even farther inland than permanent inundation (Gornitz 1991). Different factors influence storm surge strength, including the slope of the continental shelf and contours of the sea or river bed, the coast's shape, and the existence of natural or manmade barriers (Georgia Emergency Management Agency 2013). As will be discussed in greater detail below, Georgia's shallow continental shelf and basin-like coastal shape make it one of the most

vulnerable places on the East Coast to storm surge (Georgia Emergency Management Agency 2013).

Coastal Wetlands

Coastal wetlands play a vital role in the environmental and economic processes of coastal communities. Wetlands provide essential habitat and feeding grounds for a wide variety of species, play a key role in nutrient uptake, provide recreational opportunities (Jancaitas 2008), create a storm surge buffer, "prevent erosion, disseminate pollutants, and provide economic benefits to local and state governments" (Ecological Planning Group 2008). Coastal wetlands, including marshes and hog hammocks, are particularly sensitive to long-term SLR since their locations are closely linked to sea level (Guercio 2013). In low-lying coastal marshes, an "increase in the rate of sea level rise much beyond a few [millimeters] per year can result in marsh destruction because the plants there cannot respond rapidly enough to the increasing water level and drown" (Zhang et al. 2004, 42). Scientists have found that is "virtually certain that tidal wetlands experiencing submergence will continue to lose ground to the sea in response to future accelerated SLR [sea level rise] and other climate changes" (Guercio 2013, 359). In Georgia, "ecologists say that salt marsh loss is expected to be quite significant, both in terms of the area lost, and in reduced habitat for economically important local fisheries, such as shrimp, oysters and blue crabs" because Georgia lies on a low continental slope (Dorminey 2011).

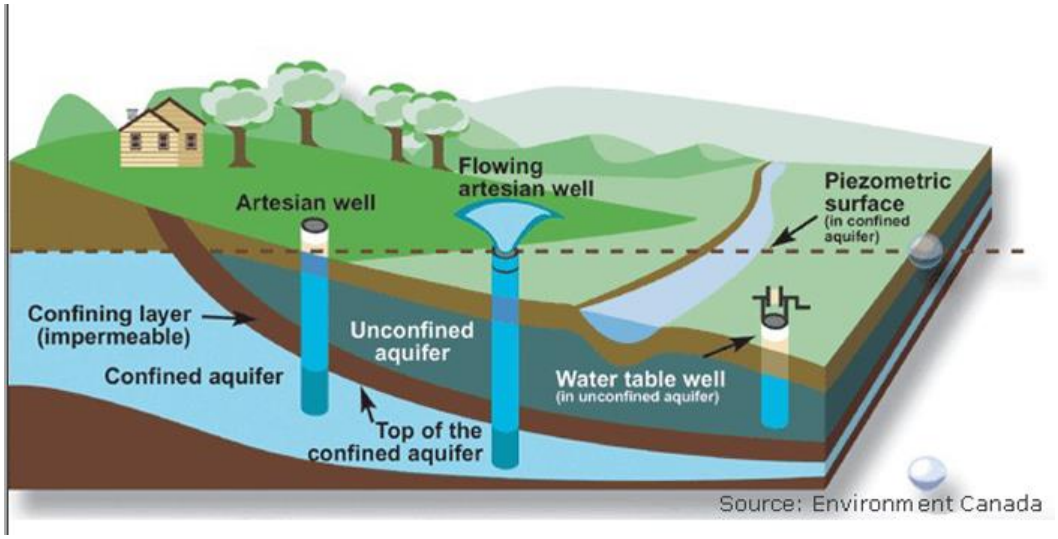
Moreover, human-driven efforts to protect local infrastructure are expected to interfere with the marsh's ability to keep up with a migrating coastline and result in the further degradation of coastal wetlands. Human development in coastal areas has interfered with the regeneration and inland migration of these important wetland ecosystems, thus exacerbating the effects of SLR on wetland ecosystems (Jancaitas 2008). "In developed coastal communities . . . accelerated [SLR] will likely cause loss of salt marshes and other important coastal resource areas" (Guercio 2013, 359). Wetland loss leaves developed and urbanized coastal areas more vulnerable flooding and storm-related erosion (Guercio 2013).

Saltwater intrusion into Aquifers

SLR may also impact freshwater aquifers. An aquifer is typically a body of saturated rock, or layers of rock, through which water can easily move. Aquifers must be both permeable and porous and include such rock types as sandstone, limestone and unconsolidated sand and

gravel. The water from aquifers is usually pumped to the surface for human use or flows to the surface through natural springs. Figure 3 depicts an aquifer and shows how fresh water from aquifers is pumped to the surface for human consumption through wells.

Figure 3: Aquifer



SLR may increase salinity in freshwater aquifers, thus contaminating a major source of the Earth's freshwater drinking supply. Saltwater penetration into coastal aquifers and estuaries could contaminate urban water supplies and affect agricultural production (Gornitz 1991). Since coastal communities are usually limited to groundwater from aquifers for their water supply, aquifer salinization could significantly impair the public water supply. Coastal communities will have to desalinate aquifer water before use, which could be prohibitively expensive for some communities to supply fresh water on their own.

The Upper Floridian Aquifer (UFA) supplies coastal Georgia counties and cities with most of the groundwater used for the public water supply and industrial needs (Foyle et al. 2001). In Savannah, Georgia, a large cone of depression has developed on the aquifer's surface from the over-pumping of groundwater. In 2000, the UFA provided approximately 350 million gallons of water per day for Savannah, Georgia (Foyle et al. 2001). The cone of depression and coastal Georgia's thin continental shelf "combine to allow sea water intrude into the aquifer" (Foyle et al. 2001). The cone of depression enhances the opportunity for seawater to migrate downward through the seabed and into the UFA (Foyle et al. 2001). This scenario could potentially lead to contamination of groundwater supplies in the long term for a large coastal population approaching 1 million people (Foyle et al. 2001).

Erosion and Property Loss

Approximately 86% of U.S. East Coast sandy beaches and barrier islands have experienced erosion over the past century (Zhang et al. 2004). Erosion is a naturally occurring process as sediment is deposited and removed on the coastal shoreline as the tide ebbs and flows. "It involves a redistribution of sand from the beach face to offshore," and is most commonly realized during coastal storm events (Zhang et al. 2004, 42). During coastal storm events, wave energy is greater such that waves are able to extend higher on beaches and dunes (further inland) and erode sediment on more upland areas (Zhang et al. 2004). Even a small vertical rise can result in seawater covering large areas of flat beaches and low-lying land. Currently, the increased erosion of upland areas is only temporary though since it is normally limited to coastal storm events. Much of the sand swept away is "returned to the beach after the storm by long-period swell waves during normal water level" (Zhang et al. 2004, 42). This natural erosion and rebuilding process could change, however, as sea levels rise. "The crucial role in erosion played by elevated water level during coastal storms clearly makes it plausible that long-term enduring increases of sea level will monotonically increase long-term erosion rates" (Zhang et al. 2004, 42).

Increased erosion could interfere with developed and undeveloped property along the coast as land literally falls into the ocean. The loss of land equates to a complete loss of property rights for private individuals and groups or state governments that own eroded property.

Geomorphology of the Georgia Coast: Why is Georgia Susceptible to Sea Level Rise?

Coastlines are constantly shifting. "Coastlines naturally shift and adjust to relative shoreline shape, availability of sediment, increases in wind and wave energy, and historically slowly rising sea levels" (Guercio 2013, 351). Approximately 81.8% of the shoreline on the Southeast Atlantic Coast lies on unconsolidated sediments; the remainder is primarily limestone in Florida (Gornitz 1991). The Southeast Atlantic total regional shore length is composed of a variety of barrier islands, marshes, and estuaries: estuaries (39.2%), barrier islands (26.1%), lagoons (22.4%) and mangroves and reefs (12.3%) (Gornitz 1991). Marshes occupy 45.2% of the coastline, of which 58.4% are located in estuaries and 25.0% along lagoonal coasts, the

remainder on reefs or back-barriers (Gornitz 1991).[3] Almost all beaches in the Southeast Atlantic region occur on barrier islands (Gornitz 1991).

The Georgia coast is characterized by numerous barrier islands and marsh areas. Georgia's "ocean-facing coast stretches for approximately 100 miles between South Carolina and Florida, yet contains over 1200 miles of shoreline because of . . . intricate tidal creeks within extensive marshes and over a thousand small back-barrier islands" (Robinson 2010). In addition to providing habitat for oysters, shrimp, crab and fish, Georgia's roughly 300,000 acres of marsh are quite important for trapping carbon, otherwise known as "carbon sequestration" (Dorminey 2011). The marsh areas provide habitat for several endangered species, such as the shortnose sturgeon, and are protected from some forms of development by Georgia's Coastal Marshlands Protection Act (CMPA). Moreover, Georgia has one of the largest tidal ranges on the Atlantic East Coast because of it broad, shallow continental shelf and concave shape of its coastline (Henry 2013). Georgia coast has a tidal range up to 8.2 feet, which is much higher than the tidal range in other states, such as North Carolina, which has a tidal range of 2-3 feet. The "tide's twice-daily ebb and flow is by far the dominant physical process along the Georgia coast" (Henry 2013, 1).

Georgia's coast is highly susceptible to SLR. Even a small amount of SLR can have a significant impact on the shoreline (Robinson 2010) because of Georgia's shallow continental shelf, high tidal ranges, and highly erodible beaches. The character of coastal landforms will be important variables influencing the precise manner and speed at which changes along the coast occur (Guercio 2013). The geological development of the Georgia coast has been significantly "influenced by the large, but cyclic, storage capacity of the tidal marshlands behind the barrier islands" (Henry 2013, 1). "Powered by the six- to ten-foot tides, nearshore waters are forced in and flushed out of the sounds through the constricted inlets between the barrier islands" (Henry 2013, 1). In general, the greatest shoreline change in Georgia occurs along the northern (erosion) and southern (accretion) thirds of barrier islands (Henry 2013). The availability of sand largely determines whether the shoreline will erode or build (Henry 2013). "In sandy shore environments, coastal headlands, spits, and barrier islands are virtually certain to erode more quickly" (Guercio 2013, 351). Over the past seventy-seven years, the "greatest net shoreline retreats have occurred on Tybee, St. Catherines, Wolf, and Jekyll islands" (Henry 2013, 1). Georgia's barrier islands provide important habitat for species, recreational opportunities for humans, and protection from the brunt of powerful coastal storms. If these barrier islands continue to erode with rising sea levels, Georgia's mainland coast will become more susceptible to erosion and to powerful coastal storms.

[3] Back barrier islands are islands located between barrier islands, while estuaries are partially enclosed bodies of water along the coast where freshwater from rivers meet and mix with salt water from the ocean.

Strategies for SLR Preparedness: Protection, Adaptation and Retreat

As sea levels continue to rise, local residents and governmental officials will face the question of how best to adapt to encroaching seas. This is called the adaptation process. The IPCC (2007) defined adaptation to climate change, and specifically to SLR, as follows:

> "Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realise new opportunities. Adaptations include anticipatory and reactive actions, private and public initiatives, and can relate to projected changes in temperature and current climate variations and extremes that may be altered with climate change. In practice, adaptations tend to be on-going processes, reflecting many factors or stresses, rather than discrete, measures to address climate change specifically .... [As used by the IPCC], adaptation practices refer to actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate. Thus, investment in coastal protection infrastructure to reduce vulnerability to storm surges and anticipated sea-level rise is an example of actual adjustments."

In general, communities can prepare for rising seas in one of three ways: (1) protection; (2) adaptation (or accommodation); and (3) retreat. Each strategy will be generally discussed in this section, and more specifically applied to Georgia's coastal communities in the recommendation section below. The specific strategy selected will heavily depend on whether the area is developed or undeveloped, and whether the law restricts actions by private individuals and governmental officials. Moreover, because each adaptation strategy imposes a cost on individuals and government, financial viability is another important factor when deciding which strategy should be adopted.

Protective measures defend against the threats of SLR, such as flooding, damage to infrastructure, and erosion (Nolan 2013). These measures are generally implemented on a smaller, site-specific scale rather than entire neighborhoods or coastal communities (Nolan 2013). Protective measures may be separated into hard or soft structural armoring options (Nolan 2013). Hard armoring options include dikes, levees, floodwalls, seawalls, revetments, bulkheads, groins, detached breakwaters, tidal barriers, and salt-water intrusion barriers (Nolan 2013). Hard armoring options may actually increase the rate of erosion since these structures tend to kill wetlands and marshes that hold uplands in place along the shore. Soft armoring options include beach renourishment, dune building, and constructed wetlands, reefs, or barrier islands (Nolan 2013). Beach renourishment, or artificial beach replenishment, is

common along ocean shores (Titus 2011), though it is expensive and may have negative ecological consequences for coastal species. Protective measures also include certain construction strategies involving site-specific design standards, including dry waterproofing and raising buildings. Dry waterproofing is meant to inhibit water infiltration by designing the exterior of a building with waterproof coating, impermeable membrane, aquarium glass or additional layers of concrete of masonry (NYC Planning Department 2013).

A second strategy to combat SLR is adaptation. Titus (2011) described adaptation (which may also be termed accommodation) as a coping strategy that allows for continued human habitation despite rising sea levels. Adaptation strategies allow for the continued development of new structures but manage risks by conditioning new development on the fulfillment of certain structural requirements to be more resilient to SLR impacts (Grannis 2011). These strategies often involve a permitting scheme and attempt to limit the amount of hard shoreline armoring because of the effects such armoring has on other parts of the coast (Grannis 2011).

A third strategy to combat SLR is retreat. Retreat policies aim to minimize the hazards of SLR by restricting, prohibiting, or removing development from vulnerable areas (Nolan 2013). Examples of retreat strategies include rolling easements, government land purchases, and setback restrictions (Nolon 2013). The government may buy coastal property or prevent development of private land outright to promote a policy of retreat. The government may also "downzone" property such that the property can be used only for park or recreation purposes, and no permanent structures would be permitted on the property. This strategy may be difficult, however, if the property sought to be downzoned is already developed. Property owners would likely resist downzoning and sue for compensation and invalidation of the downzoning action under several state and federal constitutional provisions. "Retreat may be the most effective and economically efficient method of limiting the risks of sea level rise and climate change to people and the environment" (Jancaitas 2008, 191). While retreat is common in undeveloped areas, retreat is uncommon along developed coasts because of the high costs of lost development potential, property taxes, and the like that this strategy imposes.

Why is SLR an issue for coastal communities?

Coastal areas are substantially more crowded than the U.S. as a whole, and population density in coastal areas will continue to increase in the future. Over forty percent (40%) of the United States population lives in counties along the coastal shoreline (NOAA 2013). Counties directly on the shoreline constitute less than 10 percent (10%) of the total land area (not including Alaska) in the United States, but account for 39 percent (39%) of the total population

(NOAA 2013). From 1970 to 2010, the population in these shoreline counties increased by almost 40% and is projected to increase by an additional 10 million people or 8% by 2020 (NOAA 2013).

Georgia ranks twenty-eighth (28) in terms of percentage of population living on counties that directly abut the ocean, with an average of 121 people/per square mile on the coast (NOAA 2013). In Georgia, approximately 563,967 people live in counties along the shoreline (NOAA 2013; U.S. Census Bureau 2010). Georgia's coastal counties include: Chatham, Bryan (though only approximately 2 miles of the County are located along the coast), Glynn, McIntosh, Camden, and Liberty. In Glynn County specifically, "growth in the unincorporated, as well as incorporated areas has been slow in comparison to much of the Coastal Georgia Region, with the majority of growth occurring in the unincorporated areas. The popular barrier islands of St. Simons, Little St. Simons, and Sea Island are all unincorporated. Although the islands are the most popular places in Glynn County to live, growth of these islands is restricted by a number of factors, including the price of land and housing and the amount of developable property" (DCA 2005). Though there are limiting factors, the expectation of additional development is reflected in the high prices of coastal land (Titus 2011). According to an informal search of available real estate listings in Glynn County, the average single-family residence on St. Simons Island (part of unincorporated Glynn County) was $2,750,000, with some single-family residences selling for as much as $8,500,000 (Trulia 2014).

Legal Issues Raised by SLR

Rising sea levels create many legal issues. Governments in particular face many legal questions regarding SLR, including the question of whether the government is authorized to act in response to rising sea levels. Stated another way, does a particular government have the legal authority to take action? This is especially important with regard to the federal government since it is a government of limited power, though the federal government's powers have traditionally been broadly interpreted under explicit constitutional provisions such as the Commerce Clause.[4] State governments are governments of plenary power, and are limited by their own state constitutions and powers reserved for the federal government. Local governments are creatures of the state and are typically limited to powers conveyed to them in

[4] The Commerce Clause gives Congress the power "to regulate commerce with foreign nations, and among the several states, and with the Indian tribes." U.S. Const., Article I, Section VIII, Clause III.

constitutional and statutory grants of power from the states. States vary in the amount of power, and types of power, delegated to local governments.

Furthermore, federal, state and local actors have overlapping jurisdiction in many areas of law. Oftentimes state or federal preemption laws will establish which law-federal or state-governs if laws conflict, though this is often a gray and heavily-litigated area. SLR is an area of significant conflict, and thus raises many preemption issues, because it involves issues regulated at all levels of government. Thus, another major legal question in the SLR debate is who has the authority to act-local, state, or federal actors, and whether the action taken is consistent with preexisting state or federal law. As discussed below, the federal government has done little to actively regulate against or create policies addressing climate change or SLR. SLR policies have primarily been dealt with at the state level. These issues have been primarily dealt with at the state level because tidal lands are almost always held in trust by the state for the public, and thus the state is a major stakeholder in actions involving its property. Moreover, local governments may be unable to take local action without authorization from the state, or are unsure of acting without state approval, and therefore wait until specific action is taken by the state on the particular issue. Local decision makers must also determine whether the implementation of a policy could provoke litigation, or whether a community's decision not to implement a policy could create liability for failure to act? Generally, governments have immunity from discretionary actions, and legislative officials have legislative immunities when enacting law or policy. However, exceptions to immunity do exist, and in some instances communities have waived immunity privileges.

A final legal question that permeates many of the actions contemplated by governments is whether the action is constitutional? Could the action be challenged as a taking or due process violation under the Fifth Amendment, Fourteenth Amendment or state law? Takings and substantive due process violations[5] are common challenges to land use regulations. The Fifth Amendment to the U.S. Constitution states ". . . [n]or shall private property be taken for public use, without just compensation." This is known as the Taking provision of the Fifth Amendment. The Fifth Amendment's taking provision has been incorporated through the Fourteenth Amendment to apply to state and local government actions as well as federal government actions. Thus, local, state, and government actors can be held liable for a taking under the Fifth Amendment and be required to pay just compensation for property taken. In many cases, state and local governments are also sued under state constitutional taking provisions, which may be more protective than the federal constitutional protection. Georgia's Constitution arguably provides broader protections to private property owners for the taking of private property for public use.

[5] The Due Process Clause of the Fourteenth Amendment to the U.S. Constitution provides ". . . nor shall any state deprive any person of life, liberty, or property, without due process of law."

Takings challenges will be the most prevalent challenges to this paper's suggested regulatory responses to SLR since land use regulation frequently generates claims that governments have gone "too far" in restricting private property rights. Takings challenges, in addition to other constitutional challenges, will be discussed in greater detail below.

Coastal Management Tools for Addressing SLR

A number of regulatory and non-regulatory coastal management tools exist to states and local communities in preparing for rising seas. This paper discusses four broad categories of tools available to state and local governments, and specifically available to Georgia and local governments within Georgia. These categories include:[6]

- Regulatory tools: Zoning, setbacks, building codes, mitigation standards, implementation of the National Flood Insurance Program (NFIP)

- Planning tools: Subdivision ordinances; comprehensive land development plans

- Non-regulatory tools: Transfer of Development Rights Program; coastal zone management programs

- Land ownership and management: Land acquisition and conservation; dune preservation and restoration

The use of these regulatory and non-regulatory tools depends on the area sought to be protected, and whether such area is currently developed or undeveloped.

Most regulatory suggestions for addressing SLR in this paper apply to local governments since zoning and most land use regulatory powers have been constitutionally delegated to local governments in Georgia. The planning power has also been constitutionally delegated to local governing authorities within Georgia. Thus, most of the coastal land management tools exist at the local government level. State government will play a major role in coastal management as well, however, since states have more resources than local governments and have the power to explicitly delegate certain powers and authority to local governments. Though the federal government and its agencies have less of a regulatory role compared to local and state governments, federal resources far outnumber state and local resources and therefore the

[6] A section of this list appeared in the Pace University Law Center's "Local Land Use Response to Sea Level Rise" final report (Pace Law Center 2008).

federal government has an important role in incentivizing and dis-incentivizing certain behaviors (such as through increased flood insurance rates) and funding further SLR research.

Federal and State Policies regarding SLR

This section presents policies and legislation regarding SLR that have been adopted at the federal and state levels. Though some of the policies included in this section address SLR specifically, other policies address aspects of SLR without actually stating that they are intended to combat the hazards associated with rising sea levels.

Federal Policies regarding SLR

The federal government has taken little action to combat rising sea levels or climate change (Flynn 2013). Congress has yet to ratify the Kyoto protocol, and many legislative representatives still deny that climate change and SLR exist (Flynn 2013). The policy platform changed somewhat in 2013 when the White House issued its Climate Change Action Plan. In June of 2013, President Barack Obama issued the President's Climate Action Plan, which sets forth several broad policies for addressing climate change, such as a reduction in carbon emission and readying infrastructure for rising sea levels, to ensure we "leave behind a cleaner, more stable environment" in an effort to promote intergenerational equity (White House 2013). The Climate Change Action Plan encourages federal agencies to create publicly-accessible resources regarding rising ocean waters, including detailed coastal flooding maps and interactive sea level rise maps (White House 2013). Furthermore, in 2013, federal agencies began releasing a series of Climate Change Action Plans aimed at protecting their investments along the coast from climate change impacts. Federal agencies have also started providing technical assistance to state and local communities in an effort to reduce risks associated with SLR.

In addition to executive branch policies, limited legislation has been enacted to address the unique issues facing coastal communities. In 1972, Congress enacted the Coastal Zone Management Act (CZMA) in an effort to protect coastal resources. The federal CZMA seeks to seeks to manage coastal management and improve ecological conditions in coastal areas by encouraging "the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels in the Great

Lakes, and improved predictability in governmental decision-making" (16 U.S.C. § 1452(3)). The CZMA encourages orderly planning primarily through financial incentives (grants). Coastal communities that have qualifying plans in place for coastal management are eligible to receive such grants from the federal government.

Federal flood insurance is also an important tool for protecting and dis-incentivizing coastal development. The Federal Emergency Management Agency (FEMA) administers the federal flood insurance program (NFIP) and federal hazard mitigation planning efforts under the Disaster Mitigation Act of 2000 (P.L. 106-390). The NFIP is the federal government's "primary tool for managing flood hazards through a combination of incentives and regulation" (Pace 2008). The NFIP provides, or subsidizes, flood insurance provided to commercial and residential owners that adopt appropriate construction and design standards. Communities must enact a floodplain ordinance with certain features to receive "an insurance alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods" (FEMA 2002). The NFIP will be discussed in greater detail below.

State Policies Regarding SLR

Two states in the United States have specific laws or regulations that require decision makers to consider SLR when creating policies for land use planning or development: Massachusetts and Rhode Island. Massachusetts requires new buildings within a flood zone intended for human habitation use be designed and built to incorporate projected SLR during a building's design life (310 CMR 9.37(2)(b)(2)). Projections must be based on historical rates of sea level increase in New England coastal areas (310 CMR 9.37(2)(b)(2)). Rhode Island has established setbacks for dunes, barrier beaches, and other coastal resources determined by the type of natural feature and rate of erosion. Development is prohibited, and new infrastructure is prohibited on all barrier beaches. Likewise, South Carolina has legislation and regulations in place to protect its coastal shorelines. South Carolina enacted its Beachfront Management Act in 1988 to protect its valuable coastal resources and discourage development from beach areas. The Beachfront Management Act states in its legislative findings:

> (1)The beach/dune system along the coast of South Carolina is extremely important to the people of this State and serves the following functions:
>
> > (a) protects life and property by serving as a storm barrier which dissipates wave energy and contributes to shoreline stability in an economical and effective manner;

(b) provides the basis for a tourism industry that generates approximately two-thirds of South Carolina's annual tourism industry revenue which constitutes a significant portion of the state's economy. The tourists who come to the South Carolina coast to enjoy the ocean and dry sand beach contribute significantly to state and local tax revenues;

(c) provides habitat for numerous species of plants and animals, several of which are threatened or endangered. Waters adjacent to the beach/dune system also provide habitat for many other marine species;

(d) provides a natural healthy environment for the citizens of South Carolina to spend leisure time which serves their physical and mental well-being.

(2) Beach/dune system vegetation is unique and extremely important to the vitality and preservation of the system.

(3) Many miles of South Carolina's beaches have been identified as critically eroding. (S.C. Code § 48-39-250).

The Beachfront Management Act sets forth a variety of policies, including a 40-year retreat policy (S.C. Code § 48-39-280), which establishes baselines and setback lines in designated beach zones. Certain permits are required for action seaward of the established baseline, while other permits are required for actions between the setback line and baseline. The baseline can move as beaches accrete or "renourish" through beach renourishment plans, and thus migrate to match the dynamic character of beaches. This feature of the Act is similar to a rolling easement or a rolling coastal zone management plan, and is a possible strategy for protecting Georgia's coastal resources. Rolling easements and coastal zone management plans are discussed in greater detail below.

New York has also been at the forefront of SLR planning. In 2007, the New York legislature created the State Sea Level Rise Task Force (2007 N.Y. Laws ch. 613) and directed it to develop recommendations for adapting to SLR. The task force was composed of staff from state agencies, local governments, not-for-profit groups, and private citizens appointed by members of the legislature. In December 2010, the State Sea Level Rise Task Force issued a report assessing impacts to the state's coastlines from rising seas and recommending protective and adaptive measures (Salkin 2013). The report contains, among other things, the following recommendations:

1. Adopt official projections of sea level rise and ensure continued and coordinated adaptation efforts.

2. Require state agencies responsible for the management and regulation of resources, infrastructure, and populations at risk from sea level rise to factor the current and anticipated impacts into all relevant aspects of decision making.

3. Classify areas where significant risk of coastal flooding due to storms has been identified and implement risk reduction measures in those areas.

4. Identify and classify areas of future impacts from coastal flooding from projected sea level rise and storms to reduce risk in those areas.

5. Reduce vulnerability in coastal areas at risk from sea level rise and storms. Support increased reliance on non-structural measures and natural protective features to reduce impacts from coastal hazards, where applicable.

6. Develop maps and other tools required to assist local decision makers in preparing for and responding to sea level rise.

7. Amend New York State laws and change and adopt regulations and agency guidance documents to address sea level rise and prevent further loss of natural systems that reduce risk of coastal flooding.

8. Provide financial support, guidance and tools for community-based vulnerability assessments and ensure a high level of community representation and participation in official vulnerability assessments and post-storm recovery, redevelopment and adaptation-planning processes.

9. Undertake a comprehensive assessment of the public health risks associated with sea level rise, coastal hazards and climate change including compromised indoor air quality, drinking water impacts, post-traumatic stress and other mental health problems, increases in disease vectors, impaired access to health care and loss of reliable access to food and medical supplies.

10. Raise public awareness of the adverse impacts of sea level rise and climate change and of the potential adaptive strategies.

11. Develop mechanisms to fund adaptation to sea level rise and climate change.

12. Fund research, monitoring and demonstration projects to improve understanding of key vulnerabilities of critical coastal ecosystems, infrastructure and communities from sea level rise.

13. Ensure continued and coordinated adaptation to sea level rise.

14. Seek federal funding, technical assistance and changes to federal programs to make them consistent with, or accommodating to, state policies, programs and adaptation measures related to sea level rise.

Georgia should look to what is being done in other coastal states regarding rising sea levels in preparing its own policies.

Glynn County: Current Policies Regarding SLR

Georgia and its local governments have an opportunity to implement measures to successfully adapt existing private and public development, land uses, and infrastructure to SLR. This paper uses Glynn County to illustrate the regulatory and non-regulatory tools available to decision makers in Georgia to prepare and plan for rising seas.

Glynn County is at the edge of Georgia's Coastal Plain. Due to its history of gradual formation by the receding of the Atlantic Ocean, Glynn County's soils are primarily sedimentary, composed of sands and muds (Glynn County CDP 2008). Receding ocean levels have resulted in a series of ridges that represent former shorelines at times of higher ocean levels (Glynn County CDP 2008). Glynn County is thus characterized by a series of gentle ridges running largely parallel to the current shoreline (Glynn County CDP 2008). As a result, the coastal plain has a very gradual slope upwards from the Atlantic coast and little topographical variation (Glynn County CDP 2008), which makes it highly susceptible to coastal erosion.

Currently, Glynn County has very few policies in place to protect wetlands and highly erodible areas (CDP 2008). The unincorporated County has a special zoning district, the "Conservation Preservation" zone, which applies to many of the County's ecologically-sensitive wetlands and marshes. The County's 2009 land use plan shows that many of the coastal areas are wetlands, and therefore undevelopable, though a few areas near St. Simons Island in Glynn County show high density residential uses next to the ocean. The specific zoning characteristics of Glynn County are presented in the next section. Though development has slowed in recent years due to the economic recession, it will inevitably return in highly valuable coastal housing markets. Moreover, when the housing and construction markets fully recover, Glynn County's coastal property, especially in the St. Simons area, will likely continue to be developed absent governmental regulation since current zoning allows for fairly intense residential and commercial uses along the waterfront. Zoning classifications, as discussed below, are good proxies for the type of development that can be expected to occur in a particular district since zoning regulates the permissible use and development of property.

Analysis Section: SLR in Glynn County, Georgia

This section analyzes the impact of SLR on real property in Glynn County using a 1 meter rise in sea level by the year 2110, or approximately one-hundred years into the future. The 1 meter SLR scenario used in the following projections and analysis was created by the Skidaway Institute of Oceanography to demonstrate the potential area of inundation with a 1 meter rise in the Mean Higher High Water (MHHW) surface on Georgia's coast. The base year for the model was 2010, since a 2010 digital elevation model (DEM) was used. One meter of SLR was used as a reasonable projection into 2110 based on historical tidal gauge trends and the quickening pace of SLR along Georgia's coast. This 1 meter of SLR is consistent with figures used in several Georgia Tech studio projects (Keating & Habeeb 2012; Coburn et al. 2013), projections suggested by the Climate Change Science Program (see above), and with studies showing SLR on Georgia's coast could rise anywhere between thirty centimeters to one meter by 2100. (Dorminey). Moreover, SLR is a continuous process that will not cease in 2100 or 2110; seas will continue to rise well beyond these time frames. Thus, even if actual SLR is less than the projected 1 meter by 2110, sea levels will, in all likelihood, rise to this level in the future.

This section is organized into four sections. First, I mapped projected SLR in Glynn County using the bathtub model (see Appendix A), and looked at how a 1 meter rise in sea level would affect parcels, buildings, and infrastructure in Glynn County. I separately mapped Brunswick, unincorporated Glynn County and St. Simons to provide a better visual representation of SLR. When mapping areas and properties affected by SLR, it is also important to note whether vulnerable areas are currently developed or undeveloped, and the current use of the property. This information will help planners and decision makers determine what types of land use tools they should consider using to protect or adapt to rising sea levels. For example, if land is sparsely developed, it would be easier to downzone the property, purchase it outright for conservation use, or place a conservation easement on the property compared to a more developed area in the jurisdiction that has significant infrastructure investment and investment-backed expectations for the property. The particular adaptation tools available to Glynn County decision makers are discussed in greater detail in the final section.

The second part of this section maps the current zoning categories in Glynn County, and shows which of the zoning categories will be affected by a 1 meter rise in sea level. Next, I present FEMA's flood zone maps for Glynn County, with flood zones ranging from A to X. Each category is defined and discussed. Finally, I calculated the infrastructure impacts and cost estimates associated with a 1 meter rise in sea level. It is important to note that these impacts and cost estimates extend over a 100-year planning horizon and do not necessarily occur at one point in time, since the effects of SLR are gradual. Continuing SLR past the planning horizon will

necessitate further analysis and adaptation. It should also be noted that the maps and tables provided below use two different time frames: the parcel, building, road, and zoning data are based on what is currently in place in Glynn County, whereas the 1 meter SLR scenario uses a 2110 time horizon. Most assuredly buildings will change, either in form or value, new roads will be built, and residential subdivisions will be built on currently undeveloped property. Though we cannot predict exactly how our land will develop in the future, we can use current land development patterns and future SLR data to wisely direct growth so that by 2110 our infrastructure and new development will be located in safe areas free from inundation and frequent flooding. Overall, SLR analysis provides governmental actors with a sound legal basis for using the tools at their disposal to protect vulnerable populations and properties.

The Skidaway Institute of Oceanography provided SLR data, while Glynn County's GIS Department supplied data on tax parcels, buildings, zoning, flood maps, and roads. Data was imported into ESRI's ArcMap 10.1 program for analysis and mapping. Mapping SLR is crucial for identification purposes, and to provide the public with a visual representation of how many and which parcels will be affected by a 1 meter rise in sea level. The term "affected" is used rather than inundated because not all of the parcels inundated will be completely inundated by a 1 meter rise in sea level by 2110.

On the following maps, a 1-meter rise in sea level is represented by a transparent red shading over the County's tax parcels. Thus, any parcels fully or partially shaded red will be affected by a 1-meter rise in sea level by 2110, and are termed vulnerable areas in this paper.

SLR in Brunswick, St. Simons and Unincorporated Glynn County

Figure 4 below illustrates a 1 meter rise in sea level in Brunswick, an incorporated municipality in Glynn County, by 2110. As is seen in Figure 4, most of the parcels shaded in red are along the city's marsh areas, though some of the developed portions of downtown Brunswick are projected to be affected by a 1 meter SLR.

Figure 4: One Meter of SLR in Brunswick, Georgia

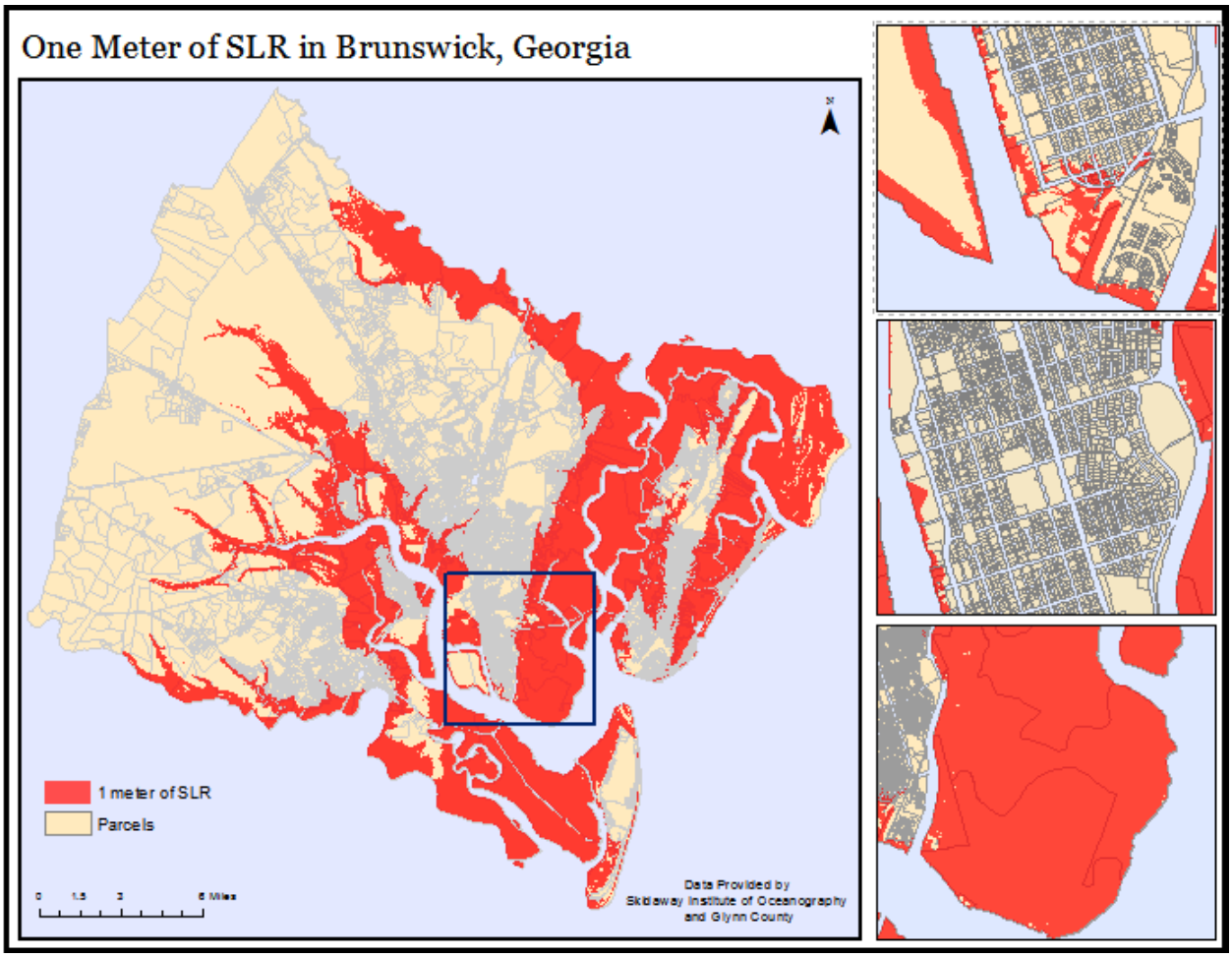


Figure 5 below represents a 1 meter rise in sea level in unincorporated Glynn County, Georgia by 2110. Again, much of the area projected to be affected by SLR is marsh area, and is currently designated for conservation use. Two sections of unincorporated Glynn County are magnified to show the impacts of SLR on more developed areas of unincorporated Glynn County. As can be seen in the two magnified sections of unincorporated Glynn County below, several parcels along the fringe of the developed core are projected to be affected by SLR.

Figure 5: One Meter of SLR in Unincorporated Glynn County, Georgia

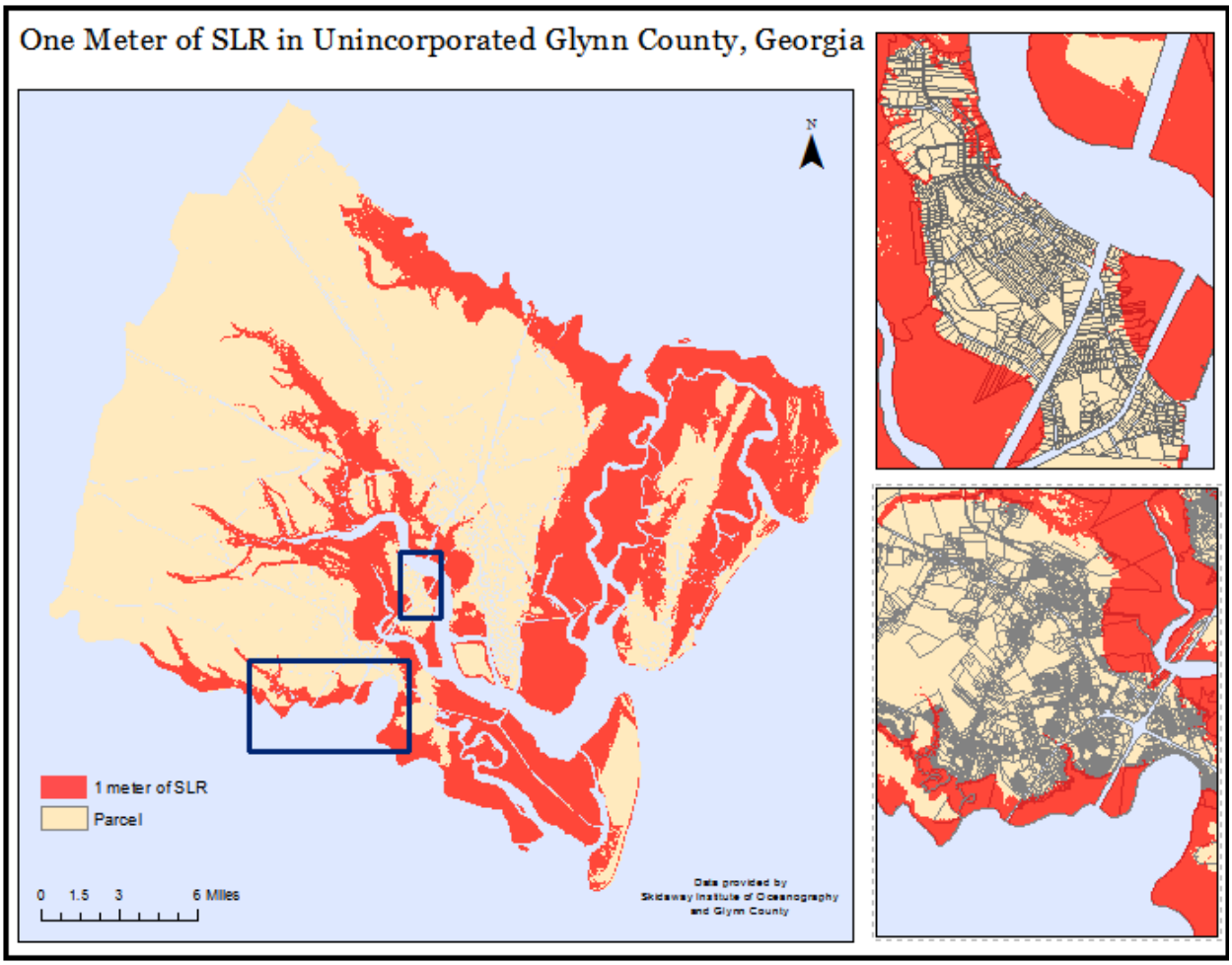
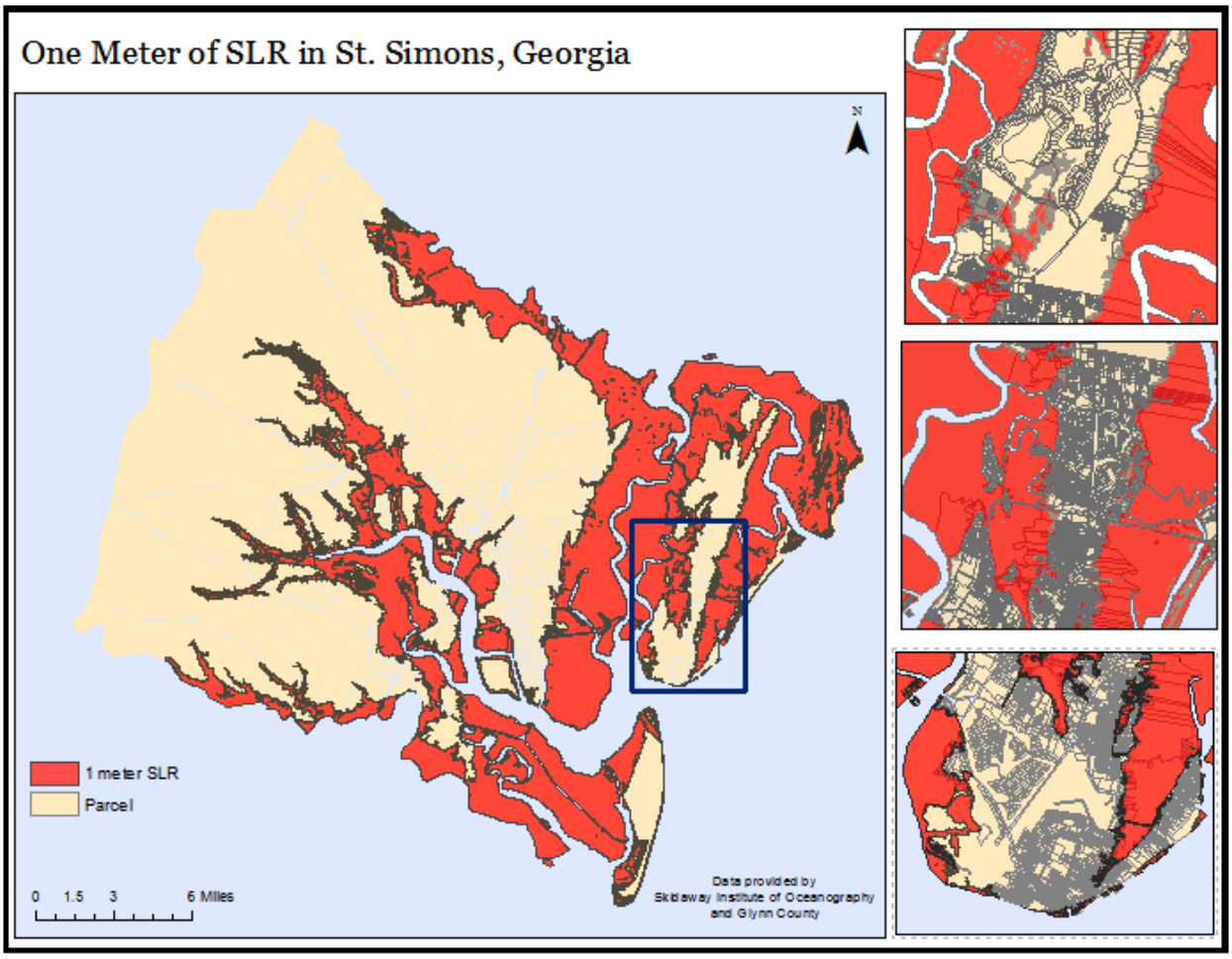


Figure 6 below represents a 1 meter rise in sea level in St. Simons, Georgia by 2110. Though St. Simons is not an incorporated municipality within Glynn County, it is singled out from unincorporated Glynn County because of its intense land development patterns (mostly high-density residential), and because many parcels in its downtown core and along its beachfront are projected to be inundated by a 1 meter rise in sea level by 2110. Three sections of the St. Simons area are magnified in Figure 6 to show the impacts of SLR on parcels in the area. As can be seen in the three magnified sections below, beachfront parcels and those located along or near the marsh inlets are projected to be affected by SLR.

Figure 6: One Meter of SLR in St. Simons, Georgia



As discussed in the introduction to this section, it is important to note whether land projected to be affected by SLR is currently developed (or developable) or undeveloped. This

information can help planners and decision makers determine the most appropriate tools available to prepare for rising sea levels. This paper uses current zoning categories as a proxy for “developed” or “undeveloped” parcels in Glynn County. Though this method may be overly-simplistic, it is a reasonable way to determine how property is currently being used or may be used in the future. For instance, if property is zoned for high-density residential use, development rights exist in the property and therefore different regulatory tools would have to be employed in protecting or adapting these areas as compared to parcels currently zoned for conservation or preservation use. Those parcels zoned for conservation or preservation use likely have no development rights remaining (especially if conservation easements have been placed on the property) and would therefore be less of a concern for local governments seeking to protect development interests or infrastructure from SLR.

Figure 7 below presents a simplified zoning map of Glynn County. The zoning categories are current as of January 23, 2014. Appendix B includes a chart of how individual zoning categories were coded for Figure 7’s simplified zoning categorization. Zoning classifications were simplified based on available uses and permissible densities on the parcels. As noted above, zoning categories are proxies for the development potential of property. Though not a perfect proxy, especially considering properties are constantly being rezoned, a property’s zoning provides information on how it is being used, or how it can be used until rezoned to another zoning classification. In Figure 7, many of the marsh inlets are already zoned for conservation, preservation or agricultural use. These zoning categories are relatively strict in permissible development, especially in the case of the conservation/preservation zoning districts which allow little if any permanent development.

Figure 7: Glynn County Zoning Classifications; January 23, 2014

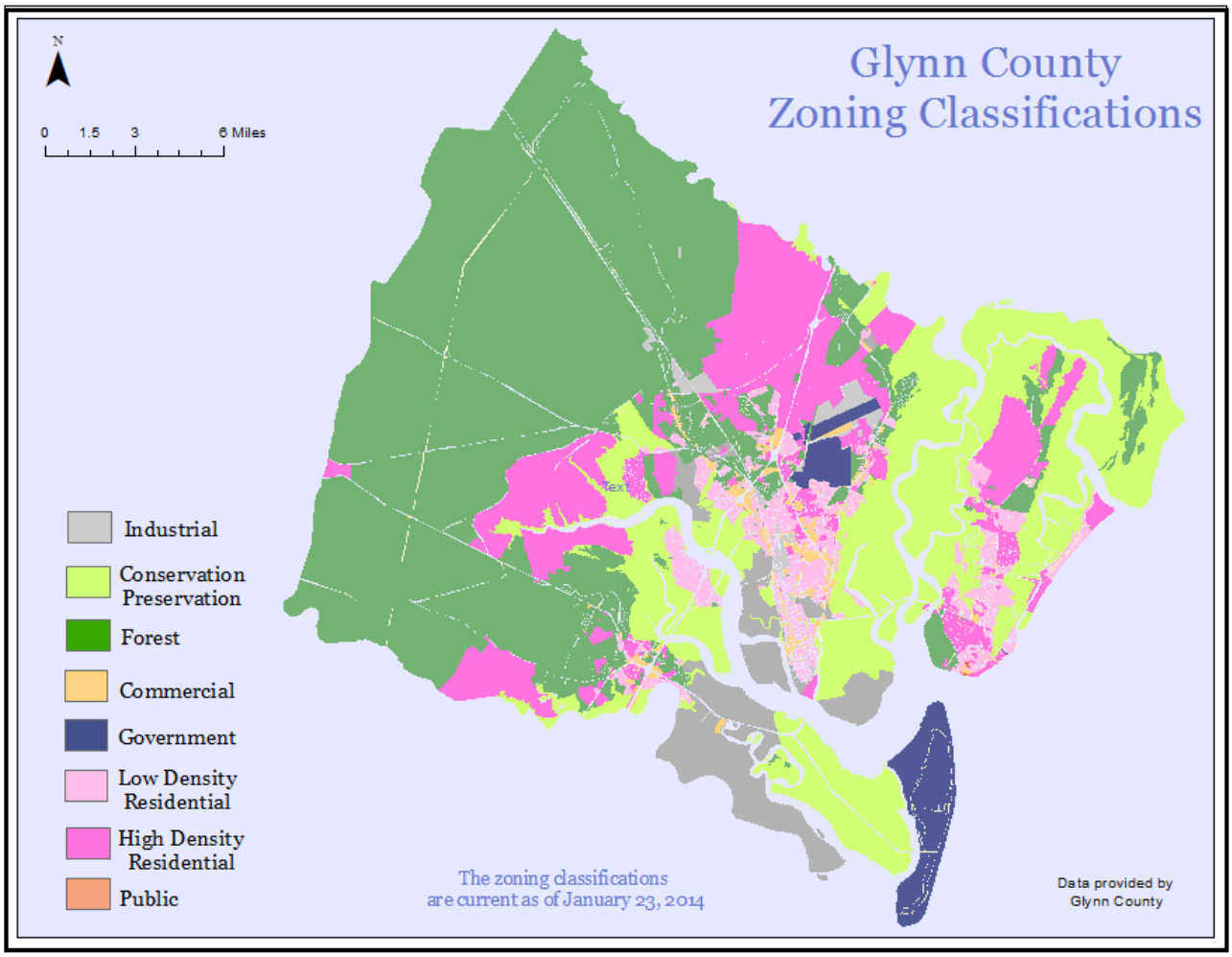
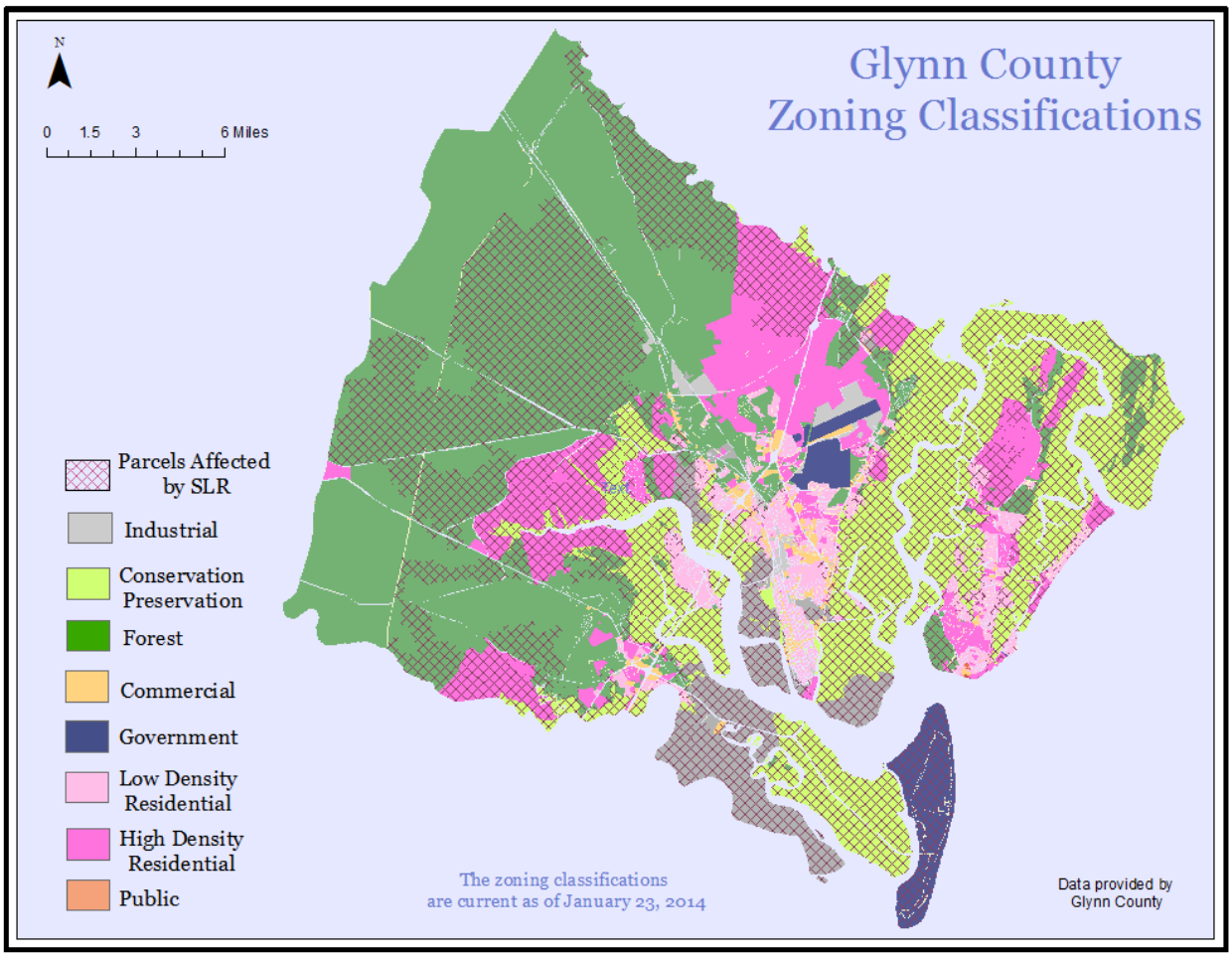


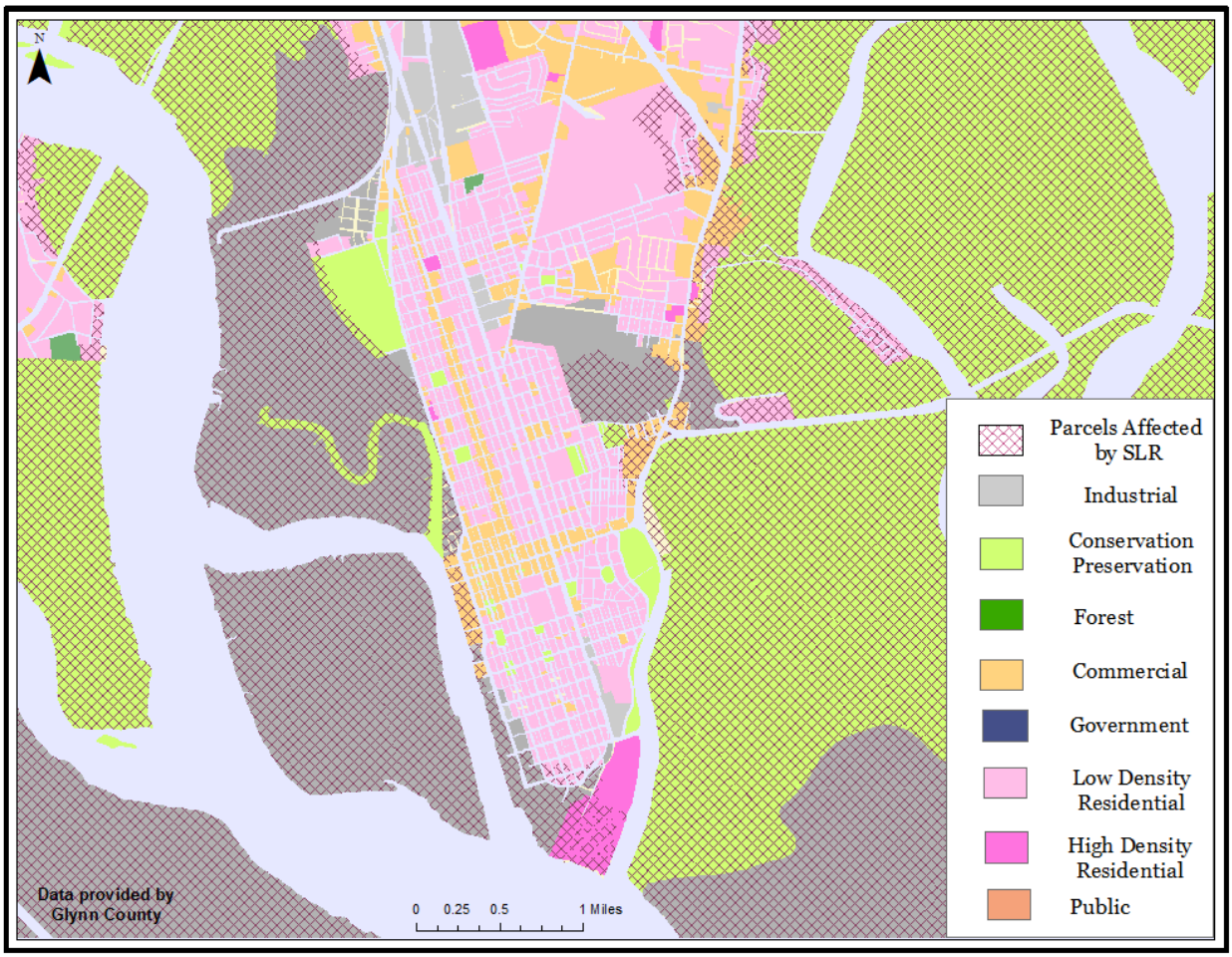
Figure 8 below adds the 1 meter SLR projections to the County's simplified zoning map. When 1 meter of SLR is overlaid on the zoning map, it is apparent that many of the parcels affected by SLR are already zoned for conservation and preservation use. As noted above, the conservation and preservation zoning classification permits very little, if any, permanent development so SLR should not flood permanent infrastructure on those parcels. Looking at Figure 8, it is also clear that several of the industrially-and commercially-zoned properties along the waterfront are also likely to be affected by SLR.

Figure 8: Glynn County Zoning Classifications with SLR Projections



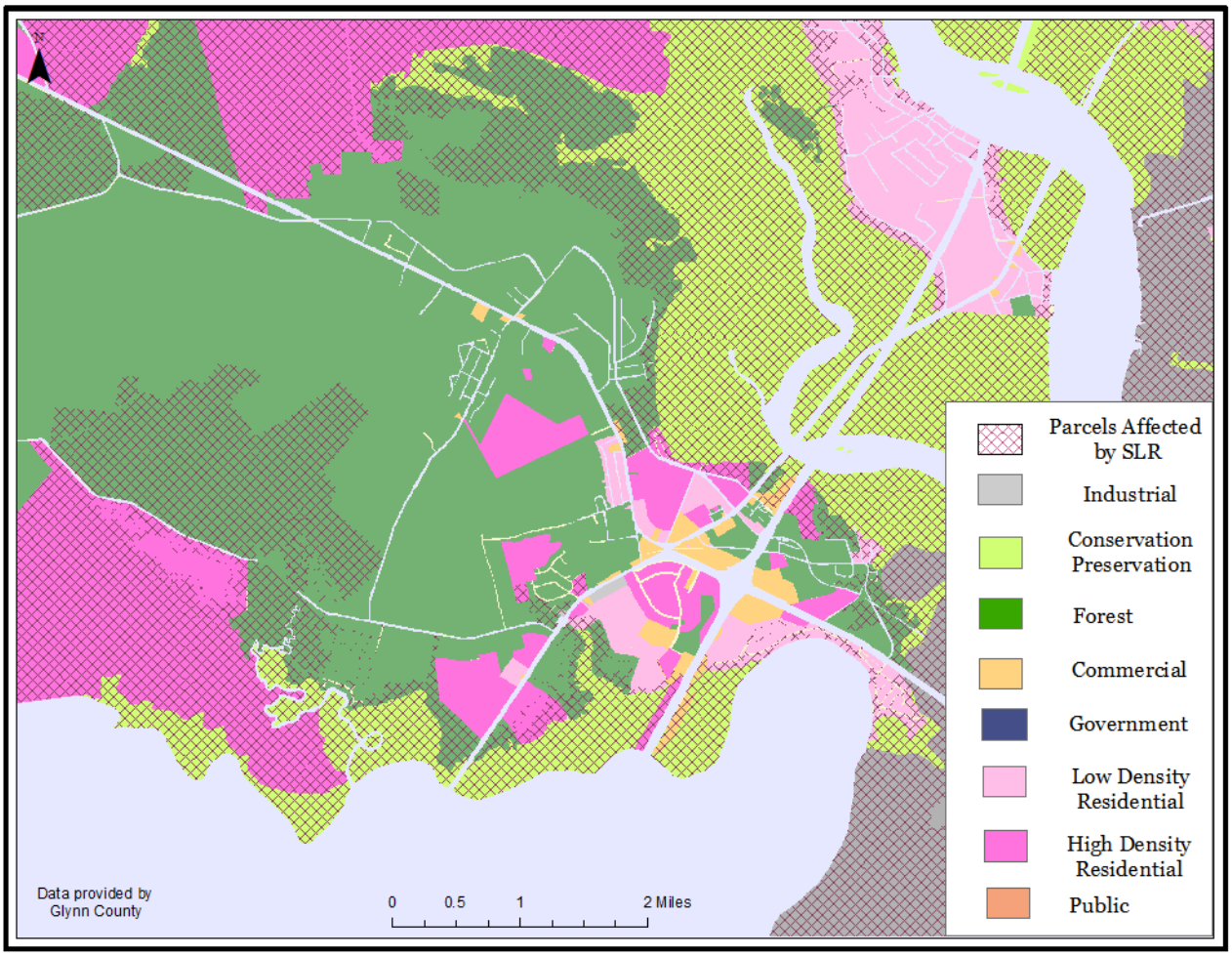
Figures 9, 10 and 11 below zoom in on the zoning classifications in Brunswick, St. Simons, and unincorporated Glynn County and overlay these zoning classifications with 1 meter of SLR. Again, it is likely by the year 2110 that these zoning classifications will change. However, current zoning classifications remain a strong proxy for where development is being directed in the County, and helps identify vulnerable areas that perhaps need to be rezoned considering the future impacts of SLR. Looking at Figure 9 of Brunswick, Georgia below, it appears that many of the industrial and commercially-zoned properties along southwest Brunswick will be affected by SLR. Moreover, there are several residentially-zoned areas in north and northeast Brunswick that likewise appear to be affected by SLR.

Figure 9: Zoning Classifications in Brunswick, Georgia with SLR Projections



Looking at Figure 10 of unincorporated Glynn County, Georgia below, it appears that high-density residential and industrial properties are most likely to be affected by SLR.

Figure 10: Zoning Classifications in Unincorporated Glynn County, Georgia with SLR Projections



Finally, looking at Figure 11 of St. Simons, Georgia below, it appears that many of the areas that will be affected by SLR are currently zoned for low-density residential and high-density residential use. Figure 11 displays several residential subdivisions located within marsh area that will likely be heavily flooded considering the fact that these subdivisions have been built on and are surrounded by marsh. This is the type of risky residential development that should be discouraged moving forward.

Figure 11: Zoning Classifications in St. Simons, Georgia with SLR

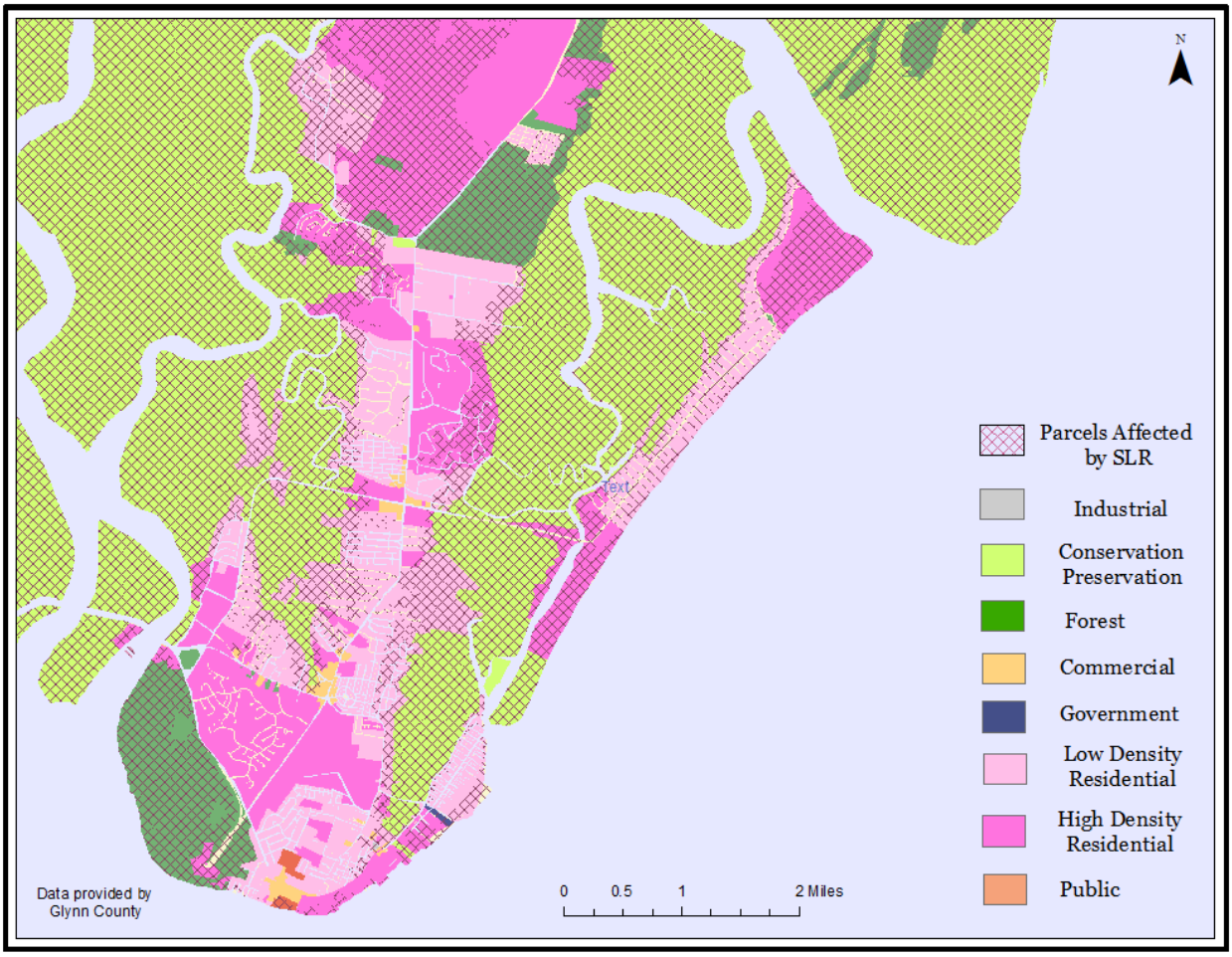


Figure 12 below shows the FEMA flood categories in Glynn County. Categories A and AE, which are subcategories within FEMA's Special Flood Hazard Areas-High Risk category, represent areas subject to inundation by the 1-percent-annual-chance-flood event. Category A zones do not include Base Flood Elevations (BFEs) or flood depths, whereas Category AE zones include BFEs and therefore employ more detailed methods for calculating flood damage than Category A zones. According to FEMA's classification descriptions, structures within Category A and AE flood zones have a 26% percent chance of during the life of a 30-year mortgage. Flood insurance is mandatory in a Category A or AE Zone, and local governments must implement floodplain management regulations in these zones.

Category VE, which is within FEMA's Coastal Hazard High Areas-High Risk category, represents areas subject to inundation by 1-percent-annual-chance flood and additional hazards due to high velocity wave action from storms or seismic sources. Local governments are required to enact floodplain management regulations in VE zones, and property owners are required to purchase flood insurance. Category X represents moderate or minimal flood hazard areas, though the terms "moderate" and "minimal" may be somewhat misleading since buildings in this category may still be flooded by severe storms or rainfall, or from inadequate coastal drainage systems. Flood insurance is encouraged and available, but is not required in the Category X zone.

Figure 12: FEMA Flood Zone Categories, Glynn County, Georgia; 2014

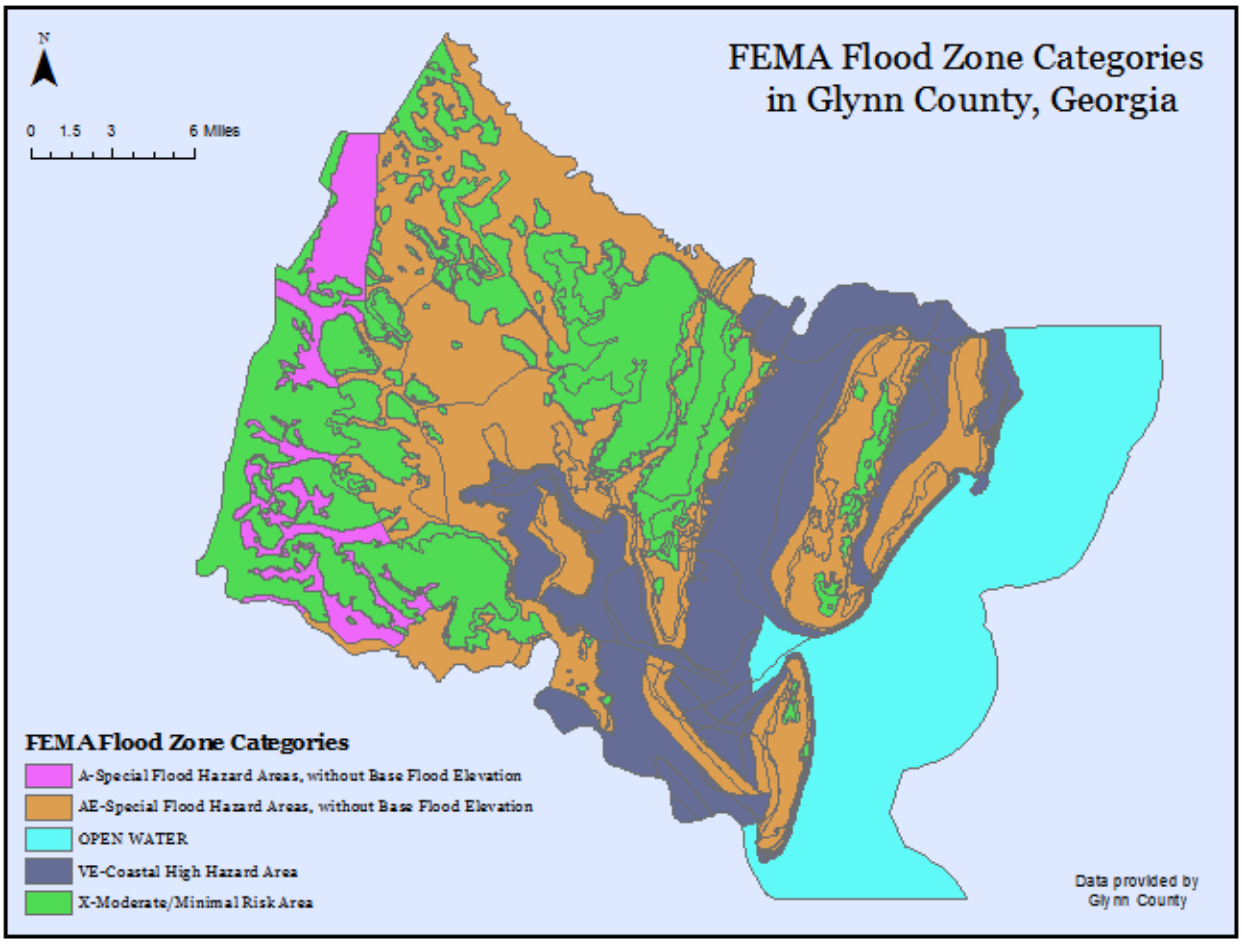


Figure 13 below overlays the SLR projections on to the FEMA Flood Zone categories for Glynn County, Georgia. As can be seen on the map, some of the parcels categorized as minimal or moderate risk for flooding (Flood Zone Category X) now have some degree of flooding with SLR, and will have to be re-categorized.

Figure 13: FEMA Flood Zone Categories, Glynn County, Georgia with SLR; 2014

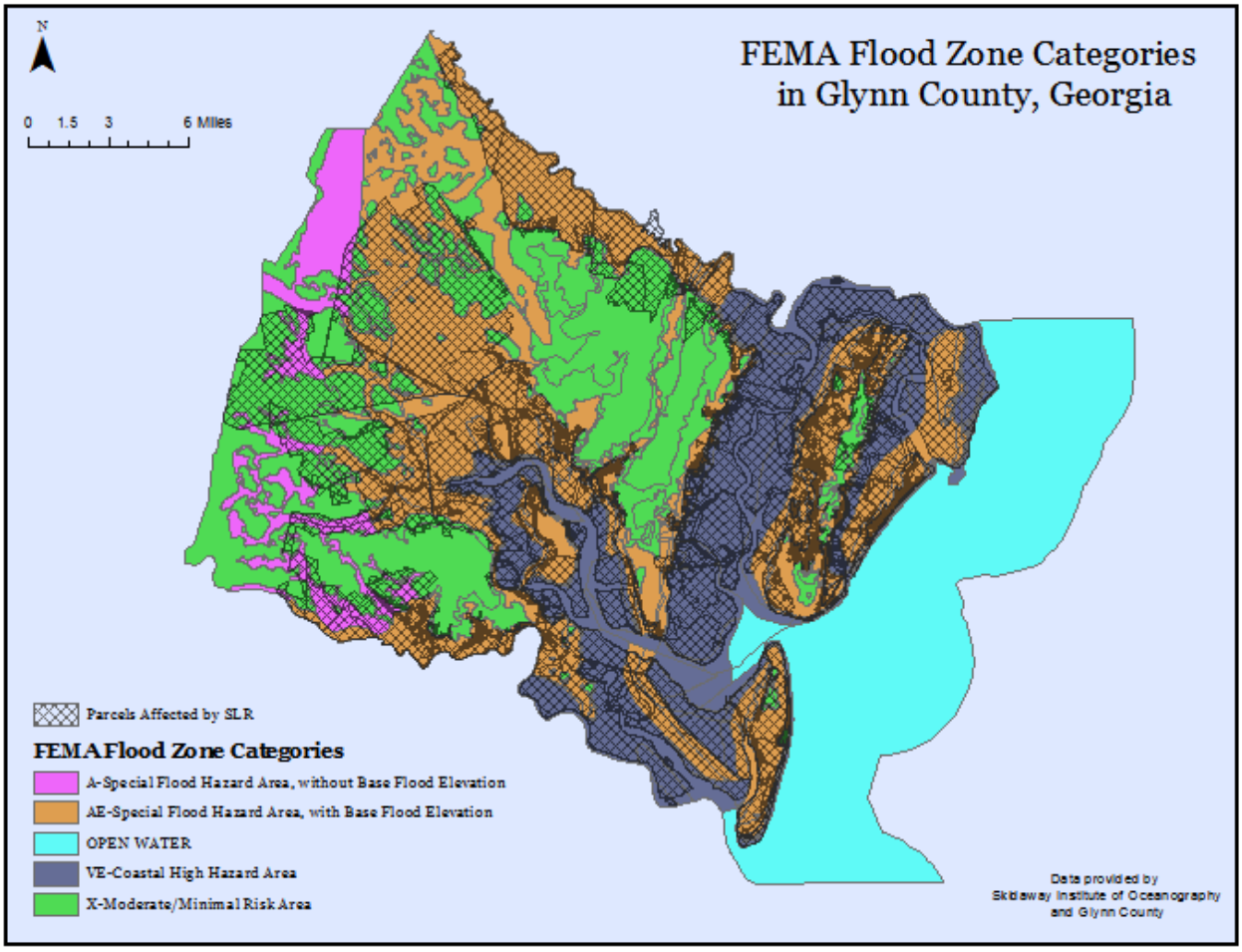


Table 1 below summarizes the total number of parcels and building projected to be affected by a one meter rise in sea level by 2110, and includes the impact of SLR on coastal property in Glynn County in terms of total assessed property value, total assessed building value, and total assessed land value. It should be noted that these figures may overestimate the financial impact of SLR since property impacted by SLR may not by wholly inundated and thus its value would not be fully diminished as assumed in Table 1 below. However, considering these figures are in terms of 2013 dollars, and that assessed values may underestimate the fair market value of property, overall the figures are good estimates of SLR's impacts on properties and property values.

Table 1: Parcels and Buildings Affected by 1 meter of SLR by 2110, Glynn County

Total Number of Parcels Affected by 1 meter of SLR	Total Acreage Affected by 1 meter of SLR	Total Number of Buildings Affected by 1 meter of SLR	2013 Total Assessed Value of Affected Parcels (in $)	2013 Total Assessed Building Value (in $)	2013 Total Assessed Land Value (in $)
4888	195,866	4855	894,684,150	389,214,746	505,469,405

Table 2 presents the road segments that will be affected by a 1 meter rise in sea level. The total number counts represent intersections with water from increased sea levels. Thus, the total count of 307 represents the number of points where water will intersect with a road, which in some cases may require the road to be elevated or bridged to accommodate heightened water levels. Though many of the "road segments" included in the total are private drives and driveways, 2 sections of GA-25, a major state highway, will be affected, as will 76 sections of light duty roads.

Table 2: Road Segments Affected by 1 meter of SLR

Roads Segments Affected by 1 meter of SLR	Type of Road
307	Total Road Segments Affected
2 (2 Segments of GA-25/Highway 17)	U.S. Highways/Interstate
76	Light Duty
38	Logging
78	Private Roads
1	Trail/Sidewalk (Youth Estate Drive/Nature Trail)
10	State Roads (Jekyll Island, GA-25)
113	Driveways/Private Easements

Table 3 includes the impact of SLR in terms of zoning classifications affected. As can be seen in Table 3, 60.4% of properties zoned for "Conservation Preservation" use will be affected by SLR. This makes sense because most of this property is already marshland and wetland area that is undevelopable or protected from development under state law. Almost half, or 45.7%, of all parcels zoned for industrial use will be affected by a one meter rise in sea level. This is likely because most of the industrial uses in Glynn County are located on low-lying waterfront areas in order to take advantage of a readily-available supply of water for the manufacturing and industrial processes that occur in these zoning districts. Another percentage that stands out is the 25.11% figure of properties zoned for high-density residential use that will be affected by SLR.

Table 3: Zoning Classifications and the Impact of SLR

Zoning Classification	Percentage of Area Zoned "Conservation Preservation" Impacted by 1 meter of SLR
Conservation Preservation	60.4%
Agricultural or Forest Parcels	25%
Industrial	45.7%
Commercial	7.8%
Low-Density Residential	14.9%
High-Density Residential	25.1%

Governmental Responses to Sea Level Rise: Available Tools and Recommendations

Governments bear the primary responsibility for protecting their citizens and property since they have the duty to protect the health, safety, and welfare of the public. This is not to say that individual property owners or non-profit organizations do not have a role to play in SLR preparedness; on the contrary, private landowners and non-profit organizations, such as land trusts or environmental groups, can play a pivotal role in SLR readiness through research, information-sharing, and private conservation measures that protect land from risky development. However, this paper argues that governments have a larger institutional role to play than private citizens in preparing for SLR, and have more tools at their disposal by which they can adequately protect the public from rising sea levels. This section focuses primarily on the regulatory tools available to local and state governments to prepare for SLR, though the federal government certainly has a large role to play in dis-incentivizing certain behaviors (such as through increased flood insurance rates) and funding further SLR research.

Governmental Authority to Act

Regulatory responses to climate change induced SLR raise a number of important issues. The first and most important question is whether the governmental body has the authority to take action. The question of authority to act depends on the governmental entity taking the action. If the actor is the federal government, the federal government actor must be able to trace its power back to a constitutional or statutory delegation of power. The federal government is one of limited powers, and derives its powers from the U.S. Constitution. Therefore, the U.S. Congress, in creating statutory law, must trace its authority to enact such legislation to a power specifically granted to it by the U.S. Constitution.

Assuming delegated powers have a constitutional basis, federal administrative agencies, such as the Federal Emergency Management Agency (FEMA), may exercise powers granted to it by Congress in its enabling legislation. Federal administrative agencies cannot act outside the scope of their delegated powers, else the actions would be considered *ultra vires* and invalidated. On the other hand, state governments have plenary power, which means states may exercise broad powers for the protection of their citizens; state governments are not limited by powers specifically granted in state constitutions. Whereas federal governments must trace the exercise of power back to constitutional grant of power, state constitutions limit

the plenary power of states. In general, therefore, states may act unless restricted by their state constitution or by statute, or if a state acts in direct conflict with a validly enacted federal law.[7]

The State of Georgia, though lacking planning and zoning power, has financial resources and competent administrative agencies at its disposal to create adaptive strategies for SLR and implement those strategies either directly or through certain funding incentives. Moreover, the State is a landowner with a proprietary interest in a number of the properties projected to be affected by SLR. In addition to certain upland, the State of Georgia also owns all land from the mean high tide line seaward.[8] As seas continue to rise, the State will theoretically start to own additional property along Georgia's coast as the mean high tide line moves inland.

Finally, the State of Georgia, through its administrative agencies, administers the Coastal Marshland Protection Act (CMPA), which is meant to protect tidal wetlands and marsh areas in coastal Georgia from activities, construction, and encroaching development that may threaten the continued viability of the marshlands (O.C.G.A. § 12-5-280). As sea levels rise, marsh may creep inland and bring additional land and structures under the Act's purview and thus under state control, though vested rights to some of this land and structures may complicate the issue of which property rights remain on land that has succumbed to marsh. This Act, and its application, may have to be revisited by the General Assembly in the future.

Local governments are creatures of the state. Local governments derive their powers from statutory grants of power from the states and from powers inferred under home rule provisions in constitutions and statutes. Though the intricacies of home rule provisions go beyond the scope of this paper, generally speaking home rule provisions provide that local governments lack inherent powers to govern but that states, through legislation or constitutional amendments, have authorized local governments to "legislatively frame an adopt their own organizational structures" (Weissman et al. 2013, § 3.3). Thus, local governments within home rule states can exercise traditional local governmental powers, including planning and zoning powers. In Georgia, the state Constitution delegates home rule power to counties,[9] while municipalities have been delegated the home rule power through the 1965 Municipal

[7] The Supremacy Clause of the U.S. Constitution states "This Constitution, and the laws of the United States which shall be made in pursuance thereof . . . shall be the supreme law of the land." In addition to direct conflict, there is also field preemption and regulatory preemption, but these legal concepts go beyond the scope of this paper. Several scholars have written on the intricacies of federal and state powers in our federalist system of government, and include specific commentary on field and regulatory preemption.

[8] An exception to this state ownership would be land that was granted to property owners by a charter or grant from the King of England prior to the creation of the State of Georgia.

[9] Ga. Const. of 1983, Art. 9, § 2, Para. 1; *see also* R. Perry Sentell, Jr., The Georgia Home Rule System, 50 Mercer L. Rev. 99 (1998).

Home Rule statute.[10] In addition to traditional local governmental functions implied through home rule powers, local governments have been delegated specific powers in charters, constitutional provisions, and statutory delegations. Most relevant to the topic of SLR, local governing authorities in Georgia have been explicitly delegated the power to plan and zone within their jurisdictional boundaries.[11] These planning and zoning powers will be discussed at length in the following sections since they are the primary tools local governments have to deal with SLR.

Who has authority to act-local, state or federal actors?

A second major question is who has the authority to take action to combat SLR-local, state, or federal governmental actors? Oftentimes, their jurisdictions overlap, though in other cases one governmental actor has exclusive power to regulate. For example, under the Coastal Marshlands Protection Act, the Georgia Department of Natural Resources has exclusive authority to issue CMPA permits for minor alterations to marshlands along Georgia's coast. Because authority to act is a central question in regulatory actions, this paper specifies which governmental level (i.e. local, state, or federal) has the authority to take such actions, and whether two or more governmental levels may overlap. It is important to note, however, that although some actions may be classified as an exclusive federal, state, or local government power, typically facts and circumstances arise that involve additional levels of government. Therefore, the classification system used in this paper to distinguish authority to act simplifies actions to make them fit neatly into particular categories. In practice, this is rarely the case and in most instances multiple layers of government are involved in an action.

Could implementation of a policy prompt litigation?

Each of the actions suggested below to prepare for future SLR will likely prompt litigation, especially at the local government level. Governmental immunity may shield the government in some instances, but because most of the tools suggested are forms of land use control tools, local governments will open themselves up to legal challenges by private property owners asserting takings, due process and equal protection challenges. To survive

[10] O.C.G.A. § 36-35-3(a) ("The government authority of each municipal corporation shall have legislative power to adopt clearly reasonable ordinances, resolutions, or regulations relating to its property, affairs, and local government for which no provision has been made by general law and which are not inconsistent with the Constitution or any charter provision applicable thereto.").
[11] Ga. Const. of 1983, Art. 9, § 2, para. 4.

constitutional scrutiny, a governmental actor must be sure scientific and technical evidence supports SLR legislation. The stronger the evidence to support the regulation or legislation, and the stronger the relationship between the regulation and what is sought to be achieved by the regulation, the more likely it is that the legislation will be upheld as a valid exercise of the government's police power to protect the health, safety and welfare of its citizens. In Georgia, legislation is presumptively valid. At the local level, land use regulation is likewise presumptively valid and therefore the burden is on those challenging the regulation to prove by clear and convincing evidence that the legislation significantly burdens private property owners and has no or little relation to the protection of the public health, safety and welfare. *Gradous v. Richmond County Board of Commissioners*, 256 Ga. 469 (1986). Practically speaking, this is a difficult burden to overcome, and provides local governments with some flexibility in drafting legislation that will adequately protect their citizens and their property from rising sea levels while not overburdening those property owners who are projected to be most affected by rising waters.

Perhaps the most significant legal issue with regard to the State of Georgia and SLR will be the State's action or inaction in response to the high tide mark moving inland, and whether action or inaction could lead to liability on the part of the State. Under the public trust doctrine, the State of Georgia owns all land from mean high water mark[12] toward the ocean. As the mean high water or mean high tide mark moves upland, will the State of Georgia acquire this additional land, or attain ownership over certain private easements? And will the State be liable for "taking" currently-private property as the mean high water mark moves inland and additional property is submerged?

The final category of actors that may take action in response to SLR is private actors or organizations. This category of private actors primarily includes individual property owners and non-profit organizations that conserve land. Though these actors are crucial for well-planned SLR strategies, this paper primarily focuses on governmental responses and regulatory tools and therefore will not discuss at length the myriad tools available to private actors. Perhaps the most valuable "tools" wielded by private actors include the outright purchase of land and preservation of land and the political pressure such private actors can impose on governmental decision makers to consider SLR in plans and regulations moving forward.

[12] The Georgia Supreme Court in *Smith v. State* judicially defined the "mean high water" at any given point along the coast as "the elevation of the mean level of high water calculated by averaging the height of all the high waters at that place over a period of 19 years." *Smith v. State*, 248 Ga. 154 (1981).

Preparing for SLR: Governmental Responses and Available "Tools"

SLR will have severe physical and fiscal impacts on coastal areas in Glynn County, Georgia. Physically, areas may be inundated or more prone to flooding and erosion. (Grannis 2011). Fiscally, governments may be required to spend substantial sums on rebuilding flooded infrastructure and eroded property (Grannis 2011). Governments can reduce coastal vulnerability and SLR impacts by planning and responding earlier rather than later after significant investments have been made in vulnerable areas. Governmental actors have several adaptive responses available to them. Table 4 below summarizes the available adaptation tools and categorizes them in three ways: (1) planning and regulatory responses; (2) land conservation efforts; and (3) market-based strategies and armoring, which include soft- and hard-armoring responses and market-based TDR programs. Several regulatory and planning tools are available to address SLR. Specifically, nine regulatory and planning tools are presented and analyzed as potential options for the State of Georgia and its local governments: (1) coastal overlay zones; (2) rolling easements; (3) rezoning/downzoning coastal property (including amortization); (4) comprehensive plan amendments; (5) Georgia's Coastal Zone Management Act; (6) land purchase and conservation easements; (7) transferable developable rights program (TDR program); (8) floodplain regulation; and (9) hard and soft armoring strategies. Table 4 characterizes each proposed response as an adaptation, protection or retreat strategy.

Table 4 also characterizes whether the tools are typically exercised at the federal, state or local government level. As noted above, jurisdictions typically overlap such that one level of government may exercise regulatory authority but must regulate consistent with state or federal law.

Table 4: Summary of Adaptive Responses for SLR

Available Adaptive Responses to SLR	Federal Jurisdiction	State Jurisdiction	Local Jurisdiction	Adaptation, Protection, or Retreat
Regulatory and Planning Tools				
Overlay Zones			X	Adaptation
Rolling Easements		X	X	Retreat
Rezoning/Downzoning (including amortization of nonconforming uses)			X	Adaptation; Retreat
Comprehensive Plan Amendments		X	X	Adaptation
Georgia Coastal Zone Management Act		X		Protection
Floodplain Regulation	X		X	Adaptation; Retreat
Land Conservation				
Conservation Easements	X	X	X	Retreat; Protection
Purchase Property for Permanent Conservation (Parks and Recreation)	X	X	X	Retreat; Adaptation
Market Based and Armoring				
Transfer of Development Rights (TDR) Programs		X	X	Adaptation; Retreat
Hard Armoring		X	X	Protection
Soft Armoring		X	X	Protection

Available Adaptive Tools: Regulatory and Planning Tools

Several regulatory and planning tools are available to address SLR. This section specifically addresses six regulatory and planning tools available to governments: (1) coastal overlay zones; (2) rolling easements; (3) rezoning/downzoning of coastal property (including amortization); (4) comprehensive plan amendments; (5) Georgia's Coastal Zone Management Act; and (6) floodplain regulation.

Coastal Overlay Zones

Overlay zones can be a valuable tool for local governments since they allow governments to maintain current zoning while addressing the unique needs of particular areas. The "overlay" zoning designation characterizes a type of geographic zoning but is not itself a zoning district with substantive components like accessory and permitted uses (Weissman et al. 2013, § 9.8.1). The "overlay" designation is general, and is used to describe additional zoning regulations placed on top of existing zoning restrictions. That is, the overlay district is placed on top of an existing zoning district and may supplement certain design standards or impose additional restrictions on the underlying zoning. Most importantly, and what often is confused with overlay zoning designations in Georgia, is the fact that the underlying zoning classification remains intact; it does not go away with the imposition of an overlay zone absent explicit action on the part of the local government explicitly rezoning or amending the underlying property. Therefore, if the underlying zoning is residential, an overlay zone that permits commercial uses cannot be placed on top of this residential zone since the commercial zoning overlay would directly conflict with the more restrictive residential uses in the underlying zoning. The overlay zone could, however, add certain design or green space requirements to the underlying residential zone since these design requirements would complement residential use.

A "coastal overlay zone" is an overlay zone used in specifically-designated coastal areas (designated on a zoning map) to maintain public access to the beach, impose site-specific design standards, or impose certain beach setback requirements. For instance, a coastal overlay zone could require future development in a zoning district to incorporate certain site-specific resilient design elements, such as dry floodproofing[13] or wet floodproofing[14] elements, to all

[13] Dry floodproofing efforts aim to stop or slow water infiltration by designing the "exterior of a building with waterproof coatings, impermeable membranes, aquarium glass, or additional layers of exterior concrete or masonry" (NYC Planning Department 2013, 38).

[14] "Wet floodproofing" strategies require structures to be built "on an enclosure elevated to a design flood elevation" where the enclosed space is designed to be enclosed in the event of a flood (NYC Planning Department 2013, 40).

permanent structures within the coastal overlay. This way, the underlying zoning could remain (residential, commercial, office-institutional, etc.), but structures could adapt to rising sea levels. It is important to note, however, that the overlay would apply to future development or the substantial redevelopment of structures rather than existing structures since the government cannot, generally speaking, apply laws retroactively as this would violate an owner's vested rights.

Coastal Overlay Zones: Authority to Enact

Local governments in Georgia have the authority to enact overlay zones. The Georgia Zoning Procedures Law (ZPL) defines a "zoning ordinance" as an "an ordinance or resolution of a local government establishing procedures and zones or districts within its respective territorial boundaries which regulate the uses and development standards of property within zones or districts" (O.C.G.A. § 36-66-3(5)). Though the Georgia Supreme Court has not explicitly held that overlay zones are zoning ordinances, local governments have treated overlay zones as such since they are enacted as ordinances and resolutions and control development regulations in specifically-identified zoning districts. Therefore, for the purposes of this paper, overlay zoning ordinances will be considered zoning ordinances under Georgia law. The Georgia Constitution delegates to all local governing authorities the explicit authority to zone and plan within their jurisdictions. Since local governments may enact overlay zones through their zoning power, they would have the authority to enact a coastal overlay zone as part of their zoning power.

Coastal Overlay Zones: Legal Challenges

Overlay zoning, like other forms of zoning, restricts private property rights and is therefore typically challenged under constitutional takings, due process, and equal protection grounds. The U.S. Constitution states that "…private property shall not be taken for public use, without the payment of just compensation" (U.S. Constitution, amend. V). This is known as the takings provision of the U.S. Constitution, and is often used to challenge land use regulatory actions as depriving a private landowner of his or her valuable property rights. The U.S. Supreme Court has divided regulatory takings claims into four categories: (1) takings that deny a private property owner of all viable use of property; (2) physical occupation of property; (3) balancing of interests; (4) land use exactions (Weissman et al. 2013, § 4.2.3). A full analysis of takings cases for each category goes beyond the scope of this paper. Federal constitutional challenges to regulatory actions are common, and should be expected if a local government seeks to regulate land development, especially if the regulation severely curtails development rights in property.

Moreover, coastal overlay zones could be challenged under Georgia law as well. The Georgia's takings test balances the "significant" detriment on the property owner from the governmental regulation and the government's interest in the regulation, and asks whether the regulation bears a substantial relationship to the public health, safety, morals and welfare. *Barrett v. Hamby*, 235 Ga. 262 (1975). If the regulation imposes too much of a detriment on the landowner without providing a strong benefit to the public (i.e. constitutionally unreasonable), a takings challenge may be successful. However, the typical remedy for a successful takings claim is invalidation of the regulation or ordinance, and an order to rezone the property to a constitutional zoning designation. Monetary damages have never been awarded in a regulatory takings case by a Georgia appellate court.

Coastal Overlay Zone: Effectiveness

A coastal overlay zone is a smart first step in preparing developed and urbanized areas for the threat of rising seas. A coastal overlay would impose certain design requirements on development, and perhaps increase the setbacks in areas that front along the beach or public access points along the beach to ensure that buildings are protected from rising water levels and public beach access is maintained. Georgia's Erosion and Sedimentation Control Act (O.C.G.A. § 12-7-1 *et seq*.) already requires a setback of 25 feet from all state waters. Since local governments are authorized to increase this setback, perhaps Glynn County could increase the setback for all new or substantially improved structures to 50 feet in the future as part of the coastal overlay ordinance.

Coastal overlays are less controversial than a downzoning process, discussed below, because the overlay would not necessarily change the underlying use of property (and thus the market value of the property); it would simply impose certain site-specific design or lot configuration standards. Overall, the implementation of a coastal overlay zone would be fairly straightforward, and would less controversial that an outright rezoning or downzoning of property so long as the regulations included in the coastal overlay zone are compatible with the underlying zoning.

Rolling Easements

The term "rolling easement" is a broad term used to describe land use policies that ensure coastal development "does not impede the inland migration of coastal resources" (Grannis 2011, 41). These forms of easements allow "ecosystems to migrate inland and allow

society to avoid the costs and hazards from protecting low lands from a rising sea" (Titus 2011, 7). As described by James Titus in a 2011 EPA Report (7) discussing the many forms of rolling easements, "A rolling easement is a legally enforceable expectation that the shore or human access along the shore can migrate inland instead of being squeezed between an advancing sea and a fixed property line or physical structure." Rolling easements can be created by state law, "rolling" conservation easements (parcel-specific), or conditions imposed on the issuance of specified development permits (Grannis 2011), and typically include local zoning protections on shore protection (i.e. hard armoring and soft armoring) and permit conditions that require public beach access to be maintained. Restrictions are dynamic and shift with natural coast erosion and accretion (Grannis 2011).

Under all forms of rolling easements, coastal armoring is limited and permanent or semi-permanent structures are required to be relocated when they start to encroach on public land (Grannis 2011). This is to ensure that wetlands are able to continue migrating inland. Since tidal wetlands support a wide variety of fish and bird species, any loss in tidal wetlands would seriously threaten these vulnerable populations (Titus 2011).

Rolling Easements: Authority to Enact

Georgia does not currently have a state statute explicitly addressing rolling easements. Several states have state legislation concerning rolling easements, all of which are grounded in the common law public trust doctrine: Maine, Texas, South Carolina, and Rhode Island (Grannis 2011). Under the public trust doctrine, each state owns coastal property up from a coastal line, usually mean high tide mark, and holds this land in trust for the benefit of the public (Grannis 2011). The Texas Open Beaches Act ("Act"), enacted in 1959, was the first state statute to codify the concept of rolling easements. The constitutionality of the Act has recently been called into action by the Texas Supreme Court, however, and its future is somewhat uncertain (Grannis 2011). In short, the Act codified the state's public trust doctrine by protecting access to the dry-sand beaches based on historic public use of those lands (Grannis 2011). The Act prohibited the hard armoring of coastlines that would obstruct public beach access and hinder wetland migration. Property owners were offered $50,000 to relocate or remove coastal structures encroaching upon the dynamic easement (Grannis 2011). After the 2010 Texas Supreme Court decision which eroded the Act's legitimacy and force, commentators have suggested that jurisdictions without rolling easement legislation can learn from the Texas Open Beaches Act and craft "rolling easement" statutes more as "rolling" coastal management statutes designed not only to protect public beach access, but also to preserve public trust lands and avoid private nuisances (Grannis 2011).

State legislation is generally more effective than parcel-specific regulation because land use restrictions apply to all coastal properties and development projects falling under the statute and individual negotiations between property owners and the government can be avoided (Grannis 2011). In general, state rolling easement legislation includes a combination of the following strategies:[15]

- Limitations on new development in vulnerable coastal areas;
- Limitations on hard armoring;
- Removal requirements for permanent and semi-permanent structures that encroach on public land or impede public beach access; and
- Real estate disclosure requirements

Rolling Easements: Legality

State enabling legislation should be enacted in Georgia to specifically delegate to local governments the authority to enact "rolling easement" regulations, and specifically set forth which actions governments are permitted to take, especially in the removal of permanent or semi-permanent structures on public land. If the power to enact rolling easement regulations is specifically delegated with clear policies and limitations on the exercise of such power, it would be more difficult to challenge local regulations enacted in response to this delegated authority. If, however, instead of delegating authority to local governments to enforce rolling easement programs the State chooses to implement and enforce a state rolling easement program for coastal Georgia, this could also be accomplished through state legislation.

Rolling easements should be established by state law before any local governments attempt to create "rolling easement ordinances" at the local level. Rolling easements will be highly controversial since they permit only temporary development and use in designated coastal areas, thereby removing fee simple ownership in property. Any state legislation regarding rolling easements should include specific findings about the environmental and safety benefits achieved by the land use regulations in order to survive legal challenges (Grannis 2011), especially considering restrictions on land use in Georgia are in derogation of the common law right to the free use of property. Legislative findings should include information on the dangers flooding poses to costal development and damage sea walls and other forms of hard armoring cause to public trust lands such as beaches and wetlands (Grannis 2011).

[15] These policies were borrowed from Grannis (2011), 41-42.

Rezoning or Downzoning (including amortization of non-conforming uses)

Perhaps the most controversial regulatory action proposed in this paper is the "downzoning" of properties in threatened coastal areas. The term "downzoning" characterizes zoning amendments that decrease the types of uses permitted on a property. That is, downzoning property restricts the permissible uses and development on property, and therefore greatly reduces the economic value of property. So, for instance, if a coastal property was zoned for office-institutional use and the government chose to downzone the property to a "parks/recreation" zoning classification, where only park use was permitted, or to an estate-residential zoning classification with a one-acre lot area minimum and a substantial beach setback, the value of the property will be reduced because development rights have been removed or significantly reduced in the property through the government's regulatory restrictions. Downzoning property often draws constitutional challenges to the government's zoning regulation.

Despite potential legal challenges, downzoning may be the most straightforward and effective means of discouraging ill-advised coastal development.

Rezoning/Downzoning: Authority

All local governments in Georgia have the authority to exercise the zoning power within their jurisdictions. The zoning power is part of a state's plenary police power, which is exercised for the public health, safety, morals and welfare of its citizens. After several piecemeal delegations throughout the early and middle twentieth century, the Georgia Legislature explicitly delegated to all local governing authorities in the State the power to zone property within their jurisdictions in the 1983 State Constitution. With this power, all local governments have the authority to enact ordinances or resolutions in exercise of their zoning power. Therefore, Glynn County would have the legal authority to enact an ordinance downzoning coastal properties projected to be affected by SLR.

Rezoning/Downzoning: Legal Challenges

Zoning changes provoke constitutional challenges from private property owners displeased with the zoning of their property or their neighbor's property. Though local governments may exercise the zoning power, the exercise of this power is still subject to certain federal and state constitutional provisions: (1) private property may not be taken for public use without payment of just compensation; (2) property may not be taken in violation of equal protection; (3) due process of law is required; and (4) freedom of speech and religion must not

be impinged absent compelling governmental interests. Most private property owners allege both federal and state constitutional violations when challenging the validity of a zoning action. Though the Georgia Supreme Court may hear and rule on federal constitutional claims, it is more likely to issue a decision on the validity of a zoning action based on Georgia law since state constitutional issues are almost entirely within the purview of the Georgia Supreme Court. *Pope v. City of Atlanta*, 240 Ga. 177 (1977). Moreover, federal courts may only hear cases that are "ripe" for judicial review (Weissman et al. 2013, § 4.3). Ripeness is a judicially-constructed doctrine, though based in the U.S. Constitution's Article III standing requirements, that requires (i) a final and determinative decision and (ii) no possibility for administrative relief at the state level before a regulatory takings challenge may be reviewed in federal court. *Williamson County Regional Planning Commission v. Hamilton Bank of Johnson City*, 473 U.S. 172 (1985). Practically speaking, therefore, very few takings cases are now heard in federal court since the second part of the ripeness test requires state compensation or relief to be sought before bringing a land use claim to federal court if such state compensation or relief exists. Since such relief and compensation exist under Georgia law, challengers must generally seek relief from land use regulatory actions in state court before seeking relief in federal court.

Zoning is considered a legislative action under Georgia law. This is not the case in other states. As a legislative act, zoning actions will be given a presumption of validity when challenged in court. Those challenging the constitutionality of a zoning action, such as a downzoning of property, must prove by clear and convincing evidence that the zoning action imposes a significant detriment on the property owner and bears an insubstantial relationship to the public health, safety, morals and welfare. *Barrett v. Hamby*, 235 Ga. 262 (1975). This is a difficult burden for challengers to overcome, especially if the government's interest in the regulation is the protection of life and property from harm. Therefore, if a local government can prove its zoning regulation benefits the public interest, its zoning decision will likely stand. However, if a local government regulation takes all economic value from a piece of property, perhaps by restricting all development on the property, a challenger would likely be successful in a takings challenge under both federal and state law. If a litigant is successful in a takings or due process challenge under Georgia law, courts may only declare the zoning action at issue void and order the local government to rezone the property to a constitutional zoning classification. It may not rezone the property to a constitutional zoning classification as this would run afoul of the State Constitution and doctrine of separation of powers.

Therefore, if Glynn County chooses to rezone or downzone coastal property, it should anticipate constitutional challenges to its zoning decision. However, if the County bases its zoning decision on sound technical and scientific data, and exercises its regulatory power in a non-discriminatory manner to benefit the public health, safety and welfare of its citizens, the County's zoning regulations should withstand constitutional scrutiny. If the County's rezoning

proposals will drastically impact private property rights, the County should be clear about the potential impacts of SLR and work with neighbors on crafting zoning regulations that balance the interests of landowners with the protection of the public. The County will want to be careful in these mitigation and negotiation processes, however, as it cannot contract away its zoning power since contract zoning is illegal in Georgia.

Rezoning/Downzoning: Effectiveness

Downzoning property may be the most effective adaptive strategy for SLR. Vulnerable property can be downzoned incrementally over the next one-hundred years so that new development is directed away from these areas, but the current property owners can still recoup some development potential in their property since the SLR time horizon extends well into the future. An incremental downzoning schedule could remove certain development permissions on designated coastal properties every ten to fifteen years, or impose additional design standards for any new development or redevelopment on the property. If the changes are incremental, the economic impact on the private property owner may be less and the government could avoid a takings challenge. This is difficult to determine, however, because regulatory takings are adjudged based on the particular facts and circumstances of an individual case. Thus, a downzoning/rezoning of one coastal property may not damage its economic value to such an extent as to invoke takings challenges, though the regulation's application to another coastal property may prompt takings litigation.

A comprehensive downzoning initiative should be well-publicized and community input should be sought since the rezoning of coastal properties will inevitably be contentious. Glynn County can expect legal challenges to its rezoning measures, but as noted above, the County should be able to enforce such stricter zoning regulations so long as it leaves some economic value in the property. If the County believes all development rights should be removed from a property (i.e. because the property is projected to be severely affected by SLR), it would be well-advised to encourage the property owner to permanently conserve the property or purchase the property itself and place a conservation easement on such property rather than attempt to remove all development rights through zoning.

A Note on the Amortization of Non-conforming Uses

Another issue that may arise with the downzoning of coastal property, and one that has yet to be specifically addressed by Georgia courts, is amortization. Amortization in the land use context refers to the gradual phasing-out of nonconforming uses and structures over a specified

period of time (Weissman et al. 2013, § 9.12.4). Amortization provisions may be included in land development ordinances or resolutions that change the permitted uses or structural requirements on property. For instance, suppose a local government chooses to eliminate adult entertainment establishments from a neighborhood-commercial zoning district. The government passes an amended zoning ordinance that eliminates adult entertainment establishments as a permitted use in the district. Thus, the use becomes non-conforming. As a non-conforming use, the existing adult entertainment establishment can remain, but it may not expand nor may any new adult entertainment establishments open in the district because they are no longer permitted. Now suppose the local government had included a 10-year amortization provision in the ordinance eliminating adult entertainment establishments in the district after ten years regardless of whether they had been established before the ordinance was passed. This ten year provision is called an amortization provision because it ensures a certain use or structure will be removed at a set future date. The provisions are controversial because they allow local governments to remove nonconforming uses and structures without the payment of just compensation. That is, the local government is able to "take" property rights (here, vested rights to use property in a certain manner) without paying the property owner for this "taking" under state or federal law. While many jurisdictions have held that "amortization provisions used for land planning are valid if reasonable" (Shank 2006, 236), others have declared amortization provisions to be per se takings for which compensation is constitutionally mandated (Weissman et al. 2013, § 9.12.4).

The "reasonableness" of an amortization provision is typically determined by balancing the loss to the private property owner against the public benefit in terminating the particular land use or structure. The amortization time schedule is adjudged to be "reasonable" by looking at the particular use or structure to determine whether the owner will be able to recoup a return on his or her investment in the property before the amortization period ends. The provisions usually include some degree of flexibility or variance provision that allows the time period to be extended if it is determined by a reviewing body that more time is needed to recoup certain investment-backed expectations. The U.S. Supreme Court has not yet ruled on the specific issue of whether amortization provisions are constitutional. Similarly, the Georgia Supreme Court has not specifically ruled on the issue, but has stated that certain land uses may be terminated after a "reasonable period." *Purple Onion v. Jackson*, 511 F. Supp. 1207, 1224 (N.D. Ga. 1981).

Amortization provisions seem well-suited for removing risky structures or uses from SLR-affected or dangerous coastal areas. If Glynn County, or any other local government in coastal Georgia, chooses to downzone coastal property it may want to include an amortization provision in its zoning ordinance that states certain uses and structures must be removed in forty to fifty years, or a time frame consistent with the anticipated flooding of property as sea

levels rise. Since the SLR time horizon extends well into the future, amortization time periods can likewise extend well into the future. The longer the time horizon, the more likely it is that the provision will be "reasonable" as private property owners will be able to recoup their investment-backed expectations in the property. Moreover, if this time period is supported by scientific data, and reflected in a comprehensive land use plan for the jurisdiction, a court may uphold the downzoning ordinance and amortization provisions as a valid exercise of the police power to protect the public health, safety and welfare. Though it may ultimately be upheld, a local government should expect any amortization provision included in a coastal zoning ordinance, or any ordinance for that matter, to be challenged.

Amendments to the Comprehensive Plan

Comprehensive planning is another adaptive tool local governments in Georgia can use to prepare for SLR. Comprehensive plans "establish general guidelines for how a community aspires to develop over time" (Grannis 2011, 12). Comprehensive plans rarely have the force of law, though that is how they were originally intended, and are instead generally implemented through zoning ordinances (Grannis 2011). These plans "can be a powerful tool by which local governments can begin to incorporate recommendations from adaptation plans into the local framework for making land-use decisions" (Grannis 2011, 12).

Comprehensive Planning: Authority

Comprehensive planning is not mandated in Georgia, though certain state funding and programmatic enrollment is conditioned on the existence of a comprehensive plan. In 1989, the General Assembly enacted the Georgia Planning Act (O.C.G.A. § 45-12-200 *et seq*.) which explicitly authorizes and promotes the "establishment, implementation, and performance of coordinated and comprehensive planning by municipal governments and county governments" (O.C.G.A. § 36-70-1). Generally speaking, a comprehensive plan sets forth official policies and principles for future development in a jurisdiction. These plans are typically created for ten to thirty years into the future. Although the Georgia Planning Act does not define a comprehensive plan, it does delegate authority to the Georgia Department of Community Affairs to define what must be included in a comprehensive plan in order for the jurisdiction to receive state funding and inclusion in state programs.

Comprehensive Planning: Legal Challenges

Legal challenges to comprehensive planning are rare. Local governments have the authority under the State Constitution to plan within their jurisdictions. Moreover, because comprehensive plans are not legally binding in most jurisdictions, though zoning consistency may be required, development permissions are typically not withheld from private landowners based on a comprehensive plan so these landowners have less of a need to file suit for development permissions.

Comprehensive Planning: Effectiveness

The strength of a comprehensive plan, and therefore its effectiveness in implementing SLR adaptation strategies, varies by jurisdiction. Some jurisdictions require zoning to be consistent with a comprehensive plan. This means that all zoning amendments must be contemplated by the comprehensive plan. For instance, if the comprehensive plan envisions certain property to be used for residential purposes in thirty years, an applicant seeking to rezone property in this area to commercial use must amend the comprehensive plan to allow for commercial use before he or she may rezone the property for commercial use. Other jurisdictions do not mandate consistency with the comprehensive plan. Thus, zoning should comply with the comprehensive plan since the plan represents official policy, but it is not required and therefore carries less legal force.

Glynn County's current comprehensive plan does not include strategies to address SLR or coastal erosion, though it does coordinate some of its coastal development efforts with the Coastal Regional Commission. Moving forward, Glynn County should consider the following actions and modifications to its comprehensive plan:

- Identify potential SLR impacts on the County's comprehensive plan
- Designate vulnerable areas that may need special protection
- Hold public meetings to discuss potential impacts with affected communities and adaptive strategies available
- Create a schedule for the implementation of adaptive strategies
- Site future public infrastructure outside vulnerable areas

Moreover, Glynn County should continue to work with the Coastal Commission in planning its SLR adaptation strategies, as the regional planning commission may be able to offer additional resources and information to adequately prepare for rising sea levels. Moreover, though the State of Georgia does not normally involve itself in local planning efforts, the State

could amend the Georgia Planning Act to specifically authorize local governments to include climate impacts, or more specifically sea level rise impacts, in their local comprehensive plans (Grannis 2011). In practice, this may delegate to the Department of Community Affairs the power to require coastal jurisdictions to include sea level rise plans in their local plans in order for the plans to be considered "comprehensive" and thus eligible for certain state funding and programming. Since the SLR time horizon extends further into the future than most comprehensive plans, local governments will have to extend their planning horizons.

Georgia's Coastal Zone Management Act

Georgia's Coastal Zone Management Act is closely modeled after its federal counterpart. Congress enacted the federal Coastal Zone Management Act in 1972 "to encourage and assist the states [effectively exercise] their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone." 16 U.S.C. § 1452(2). The federal Act provides a comprehensive framework for the management of land and water resources in coastal zones and encourages states to voluntarily adopt their own coastal zone management plans. States which have enacted such coastal zone management plans are eligible for certain federal funding and programs so long as the coastal management plans satisfy the federal law's minimum requirements. Thus, the federal Act does not impose strict regulations, but more so promotes certain policies and rewards those coastal communities that comply with the Act's minimum standards. To be eligible for funding, the Act requires states to create plans with specific elements (16 U.S.C. § 1455(d)), approval of the plan by the state's governor, and designation of one state agency to administer the coastal zone management program. 16 U.S.C. § 1455(d). Of particular relevance to this paper is the fact that the federal Act explicitly requires state programs to consider SLR in their coastal management plans. The entire federal Coastal Zone Management Act, and its requirements for federal funding, are located at 16 U.S.C. § 1451-1464.

In 1998, Georgia adopted a coastal zone management plan that was approved by NOAA in order to reduce coastal pollution and erosion, and better manage expanding coastal populations. O.C.G.A. § 12-5-321. The Act tasks the Georgia Department of Natural Resource's Coastal Resources Division to administer and monitor Georgia's Coastal Management Program (CMP). O.C.G.A. § 12-5-323. The current CMP includes a focus on public beach access, wetlands and public land conservation, and the creation of a more resilient coastline that is well-prepared for natural hazards. SLR has been an important component of the CMP, and a three-year research project on SLR helped develop a Coastal Hazards program within the CMP.

Moreover, the CMP's Coastal Incentive Grant Program has provided several grants for SLR-related research and projects to increase knowledge and resources about SLR-related hazards and vulnerable areas. Thus it appears that the State of Georgia, through its CMP, has recognized the threat of SLR and is attempting to create a regional coastal strategy through the Coastal Hazards Program.

Coastal Zone Management Act: Recommendations

Georgia's Coastal Management Program (CMP) acknowledges SLR, and has called on local and state decision makers to take SLR into consideration when developing future coastal development policies. Moreover, the CMP has provided grants and financial resources for the continued study of SLR along Georgia's coast. Therefore, it appears that the CMP has incorporated SLR into its policies, though these policies are not necessarily binding on local governments. The CMP should continue to fund SLR research and assist local governments in coastal Georgia develop well-reasoned and comprehensive adaptive strategies for continued SLR.

Updated Floodplain Regulations

Localities could use their local police power to regulate floodplain to implement adaptation strategies (Grannis 2011). A floodplain is defined as "normally dry land areas susceptible to a general or temporary inundation from the overflow of inland or tidal waters or the unusual and rapid accumulation or runoff of surface waters from any source" (Zeigler 2005, § 7.2). Flood plains are closely associated with wetlands and marshlands and often have overlapping ecological functions (Zeigler 2005, § 7.3).

In 1968, Congress enacted the National Flood Insurance Program (NFIP) to help property owners financially protect themselves from floods associated with coastal storms and heavy rains. The NFIP is voluntary and offers federal flood insurance to homeowners, businesses, and renters if the community in which they live takes part in the NFIP. The availability of flood insurance through the NFIP encouraged many local governments to enact special floodplain regulations. In order to participate in the NFIP, local communities must enact floodplain ordinances with specific regulations that meet or exceed FEMA's national standards to reduce risks associated with flooding. Localities must "adopt and enforce floodplain management ordinances that meet minimum program requirements for regulating new construction in 'special flood hazard areas' as mapped by the Federal Emergency Management Agency

(FEMA)," which is the agency tasked with administering the NFIP, in order to enroll in the NFIP (Grannis, 2011, 20). That is, local governments must regulate development in floodplain-designated areas to be enrolled in the NFIP. If a community satisfies NFIP requirements, federal flood insurance is available to that community.

FEMA creates flood insurance rate maps (FIRMs) which divide floodplains into zones based upon their susceptibility to flooding (Grannis 2011). Glynn County's flood category zones are shown and explained in greater detail in the Analysis section above. The NFIP requires local government to include additional regulations in special flood hazard areas (SFHAs), which are high risk areas that include A-Zones and V-Zones, both of which are described above. For example, NFIP minimum standards require that the lowest floor of a residential structure in an A-zone be raised to or above base flood elevation and be designed to allow flood waters to exit (Grannis 2011). Non-residential structures in A-zones may be elevated or floodproofed, which is a water-tight form of design that uses "special coatings and sealings to make walls impermeable to floodwater, and mechanical, electrical, and plumbing equipment (such as toilets) must be elevated or protected about flood damage" (Grannis, 2011, 23). In V-zones, design requirements are more stringent and require structures to be built on "pilings or columns so that the lowest floor is elevated above the base flood elevation including storm surge" (Grannis, 2011, 23), and anchored to withstand wave action and wind.

FEMA provides a model floodplain ordinance which most local governments have adopted. However, generally speaking, FEMA's floodplain ordinances only include design elements which must be imposed on development in SFHAs, rather than use restrictions (Grannis 2011). Moreover, the current NFIP does not include SLR impacts because FEMA includes only historical flood data that do not take into account SLR. Glynn County has a flood hazard mitigation ordinance, which applies to all SFHAs as shown on the official County map. The County requires special development permits for construction in designated SFHAs. Moreover, the County includes specific design elements, such as elevated structures and heating/cooling equipment, on all new or substantially modified structures. Glynn County, Georgia Code, § 2-5-136. In areas of extremely high risk, setbacks from the waterfront are also required. Glynn County, Georgia Code, § 2-5-140. The County's design elements and setbacks are also required for new subdivisions. Glynn County, Georgia Code, § 2-5-141. Critical facilities, defined as nursing homes, energy generation facilities, emergency operation centers, and hazardous waste storage tanks, are not permitted in the floodplain. Glynn County, Georgia Code, §§ 2-5-142, 2-5-125.

Updated Floodplain Regulations: Recommendations

As sea levels continue to rise, the number of properties designated as high risk areas will likely increase, and thus the floodplain regulations will extend to additional properties. Glynn County's floodplain regulations include resilient design strategies for structures to increase their capacity to withstand flooding. Glynn County requires structures in high risk areas to be elevated, and further permits the placement of "critical facilities" in vulnerable areas. In addition to these design strategies in the floodplain regulations, and exclusion of critical facilities, Glynn County could also consider prohibiting certain uses in the floodplain altogether. In this way, the floodplain ordinance would have certain characteristics of a zoning ordinance, though floodplain ordinances are not properly characterized as zoning ordinances under Georgia law. If Glynn County was to prohibit certain uses in floodplains, perhaps it could start by prohibiting incredibly dense development or adding additional infrastructure to its critical infrastructure list, such as primary arterial roads, schools, or water treatment facilities.

Available Adaptive Tool: Land Acquisition and Conservation Easements

In this section, I consider an adaptive strategy that is best employed in undeveloped areas, or areas most immediately affected by SLR, since the strategy involves removing all development rights from land: land acquisition and permanent conservation. It may be prohibitively expensive to purchase developed property, and the use of eminent domain to attain this land may raise legal challenges. Land acquisition and permanent conservation may be initiated by governmental actors or private citizens, though the lucrative tax benefits of permanently conserving land are only available for private individuals and groups. This is considered a "retreat" strategy since it is removing investment and development potential from vulnerable areas rather than attempting to protect these areas from rising seas.

Land Acquisition and Conservation Easements

State and local governments can use public dollars to acquire and conserve property as an exercise of their police power. Acquisition funds typically come from taxes, fees or the sale of government bonds (Grannis 2011). State and local governments could also use their eminent domain power to acquire the property, though this may invoke challenges from affected

landowners who may feel the compensation paid for the property is not "just compensation" as is required under the state and federal constitutions. Moreover, if eminent domain is used to acquire property, the government exercising such power will need to ensure that the property is put to public use. Since eminent domain for open space or park creation is typically controversial, a government would be well advised to convince a landowner to voluntarily sell property. Though this paper focuses on governmental actions, it should be noted that private individuals and groups can also acquire property and place a conservation easement on the property to preserve its conservation values and remove any development potential.

Once property has been acquired, the government may place a conservation easement on the property to ensure it is never developed. Generally speaking, a conservation easement is a legally binding agreement between a property owner and government or nonprofit that that limits the use of a particular property to conserve its natural value (Weissman, et al. 2013). Though the easement negates development rights in the property, the property may still be used for park use, green space, and similar low impact uses consistent with conservation or preservation intention. As noted above, individual landowners may acquire property and place a conservation easement on the property to protect its conservation value. If a private individual or group places a conservation easement on the property, he or she may receive significant tax benefits under federal and state law. The federal tax code permits a charitable deduction for qualified conservation contributions, which include "conservation easements" since they are "qualified real interests in property" made to a qualified organization for conservation purposes. (26 U.S.C. § 170(h)(2)); Weissman, et al., 2013). Moreover, Georgia offers competitive tax benefits to private individuals or groups under the Conservation Tax Credit Act of 2006 (O.C.G.A. § 48-7-29.12), which provides individuals and corporations who have placed an eligible conservation easement on their property to receive up to $250,000 (individuals) or $500,000 (corporations) in tax credits that may be used against their state income taxes. Conservation easements are "eligible" for state tax credits if they satisfy all requirements set forth in Georgia's Uniform Conservation Easement Act (O.C.G.A. § 44-10-1 *et seq*.).

Land Acquisition and Conservation: Recommendations

As sea levels continue to rise, an increasing number of properties will be inundated or affected by rising water levels. Land acquisition and conservation is a relatively straightforward method of protecting developed and undeveloped areas from flooding by purchasing such property, and thus providing the landowner with fair compensation for the lost development potential in the property. However, land acquisition is expensive and may be prohibitively so for local governments. The State of Georgia and federal government have more resources for

the purchase of property, but may be unwilling to do so because such actions are limited in geographic scope and may not rise to the level of state or federal concern necessitating the expenditure of state or federal funds. The best option would be for Glynn County to encourage private individuals and groups to voluntarily conserve vulnerable lands, and perhaps assist in providing information on the lucrative federal and state tax benefits associated with such conservation actions. Moreover, conservation strategies could be combined with a TDR program (*see below*), though enrollment in a TDR program may affect one's tax status under federal or state law.

Available Adaptive Tools: Market Strategies and Shoreline Armoring

Several market-based strategies are available to address SLR. This section will specifically focus on transfer of development rights (TDR) programs as these programs have the potential to mitigate some of the negative financial impacts of SLR when development rights are lost in a property. Next, shoreline armoring strategies are discussed as possible protective strategies for highly developed areas. Shoreline armoring may have significant negative environmental impacts, but may be the best tool for protecting highly developed areas where owners have not yet recouped investment-backed expectations in property, or areas where critical facilities, such as power plants, water treatment plants, or emergency management offices, are located since these facilities represent large, critical investments that need shielding from rising seas until they can be relocated.

Transfer of Development Rights (TDR) Programs

Transferable development rights (TDR) programs are market-based programs that shift development rights from a less developed "sending area" to a more developed "receiving area" (Nelson 2011). Development rights are part of the "bundle of rights" fee simple landowners have in their property, along with timber rights, mineral rights, water rights, the right to use, the right to alienate, and certain access rights (Nelson 2011). TDR programs are generally created on the local government level, though several local governments can enter into a TDR program to create a cross-jurisdictional program under Georgia law. This is discussed in greater detail below.

TDR programs include "sending" and "receiving" areas. Sending areas are generally rural, ecologically-sensitive, or undevelopable areas where intense development is discouraged. Development rights in "sending area" properties are sold to "receiving areas," which can then be purchased by developers or property owners looking to increase density in receiving areas. Once development rights are sold from a property, a conservation easement or similar form of restrictive covenant is placed on the property so that it cannot be later developed. Landowners in the sending areas are financially compensated for permanently conserving their properties by selling these rights to the receiving area. Developers in receiving areas are financially motivated to purchase available development rights because it allows them to increase density (and therefore gain a larger return on their investment) on projects in more urbanized settings. The TDR program may allow developers to use the development credits to increase floor-to-area ratio, reduce setback lines, or increase lot coverage percentages in a zoning district. In order for a TDR program to be effective, a local government must clearly designate "sending" and "receiving" areas, and clearly describe how development rights or credits can be used in designated receiving areas. Moreover, receiving areas should only include zoning districts which permit substantial density, such as a commercial district, since increased density permissions could be incompatible if used in a traditional residential area.

TDR Programs: Legal Authority to Enact a TDR Program

Local governments in Georgia are legally authorized to enact TDR programs. The Georgia General Assembly has explicitly delegated to local governments the power to enact TDR programs (O.C.G.A. § 36-66A-1 *et seq*.). Under Georgia's Transfer of Development Rights Act, the governing body of any municipality or county may establish by ordinance procedures, methods, and standards for the transfer of development rights within its jurisdiction subject to the consent and approval of property owners of the sending and receiving properties (O.C.G.A. § 36-66A-2(a), (b)). The statute defines "development rights" to include:

> "the development that would be allowed on the sending property under any comprehensive or specific plan or local zoning ordinance of a municipality or county in effect on the date the municipality or county adopts an ordinance pursuant to this chapter. Development rights may be calculated and allocated in accordance with factors including dwelling units, area, floor area, floor area ratio, height limitations, traffic generation, or any other criteria that will quantify a value for the development rights in a manner that will carry out the objectives of this Code section" (O.C.G.A. § 36-66-1(1)).

The Act further defines a "sending property" to include "a lot or parcel with special characteristics, including…a flood plain; natural habitats; wetlands; ground-water recharge area; marsh hammocks…" and "receiving property" to include "a lot or parcel within which

development rights are increased pursuant to a transfer of development rights…and shall be sufficient to accommodate the transferable development rights of the sending area" without substantial adverse effects on neighboring properties (O.C.G.A. § 36-66A-1(4); O.C.G.A. § 36-66A-1(6)). Currently, very few Georgia localities have TDR program in place. Chattahoochee Hills, in southern Fulton County, offers an example of a government-sponsored TDR program, though the sending and receiving areas are somewhat different than those that would likely apply in coastal areas.

In coastal areas, a TDR program could define sending areas to include coastal areas threatened by SLR. Sending areas could also include ecologically-sensitive wetland and marsh areas that serve as critical habitat for coastal species. Receiving areas could include more developed, commercial areas in downtown districts that are not projected to be affected by sea level rise. A local government would first need to designate which properties would be considered "sending areas" under the program. Property owners in both the sending and receiving areas must approve the designation (O.C.G.A. § 36-66A-2(b)). According to state law, a TDR ordinance must provide:

> (1) The issuance and recordation of the instruments necessary to sever development rights from the sending property and to affix development rights to the receiving property. These instruments shall be executed by the affected property owners and lienholders and recorded in the county superior court clerk's office and in a separate registry maintained by the municipal or county governing authority;
>
> (2) The preservation of the character of the sending property and assurance that the prohibitions against the use and development of the sending property shall bind the landowner and every successor in interest to the landowner;
>
> (3) The severance of transferable development rights from the sending property and the delayed transfer of development rights to a receiving property, which may include the transfer of development rights in accordance with any transfer ratio established by the local government for sending areas, receiving areas, or both;
>
> (4) The purchase, sale, exchange, or other conveyance of transferable development rights prior to the rights being affixed to a receiving property;
>
> (5) A system for monitoring the severance, ownership, assignment, and transfer of transferable development rights;
>
> (6) The right of a municipality or county to purchase development rights and to hold them for conservation purposes or resale;

(7) The right of a person to purchase development rights and to hold them for conservation purposes or resale;

(8) Development rights made transferable pursuant to this Code section shall be interests in real property and shall be considered as such for purposes of conveyancing and taxation. Once a deed of transferable development rights created pursuant to this Code section has been sold, conveyed, or otherwise transferred by the owner of the parcel from which the development rights were derived, the transfer of development rights shall vest in the grantee and become freely alienable. For the purposes of ad valorem real property taxation, the value of a transferable development right shall be deemed appurtenant to the sending property until the transferable development right is registered as a distinct interest in real property with the appropriate tax assessor or the transferable development right is used at a receiving property and becomes appurtenant thereto;

(9) A map or other description of areas designated as sending and receiving areas for the transfer of development rights between properties; and

(10) Such other provisions as the municipality or county deems necessary to aid in the implementation of the provisions of this chapter (O.C.G.A. § 36-66A-2(c)).

Once a local government has drafted an appropriate TDR ordinance, it must hold public hearings regarding the proposed TDR ordinance (O.C.G.A. § 36-66A-2(d)). Additional public hearings are encouraged to provide with public with adequate opportunity to proffer comments and suggestions. Notice requirements for the public hearings are nearly identical for this process as for zoning amendments. Notice must be published in a newspaper of general circulation in the jurisdiction 15 but not more than 45 days before the date of the public hearing. After a properly-noticed public hearing, a TDR program may become effective "upon the recording of the conveyance with the appropriate recording authorities and the filing of a certified copy of such recording with the local governing authority of each political subdivision in which a sending or receiving area is located in whole or in part" (Weissman et al. 2013, § 11.3.4.1). Finally, Georgia's TDR law encourages and authorizes multi-jurisdictional cooperation through intergovernmental agreements for the purpose of enacting ordinances which allow the transfer of development rights between jurisdictions.

TDR Programs: Effectiveness

A TDR program would be an effective tool to use in coastal areas affected by SLR. A TDR program could be implemented in isolation or in conjunction with a comprehensive land use regulatory program, such as zoning changes or plan amendments (if the comprehensive plan is legally binding in a jurisdiction). The goal of a program could be to shift development potential

from areas where SLR threatens development to safer locations, or to provide a form of "compensation" for property owners that suffer SLR-related flooding and wish to protect their financial investments in their property by allowing development elsewhere. Therefore, a TDR program can be beneficial to both private property owners and local governments. From the local government's perspective, it is protecting the health, safety and welfare of the public by allowing for development rights to be transferred to safer areas. It is therefore discouraging unsafe development. Additionally, private landowners benefit because they have a favorable alternative to losing their property, including its development potential, to SLR or to unfavorable government regulation (i.e. downzoning that severely limits development on property). Although TDR programs offer many benefits to local governments and private landowners, the programs are difficult to implement and administer. Hence why many local governments have been hesitant to enact such programs thus far.

Despite their complexity, TDR programs should be explored as a possible tool for adapting to rising sea levels. Because Glynn County does not currently require zoning to be done in accordance with a comprehensive plan, the best use of a TDR program may be an amendment to the comprehensive plan (discussed below) which indicates the future use of those parcels affected by SLR would be for parks, recreation, or similar low-impact uses. This signals to property owners that the local government discourages development in these areas, but does not necessarily restrict future development through zoning regulations since zoning need not be in accordance with a comprehensive plan. Thus, development rights still exist on the property, and these rights could be sold to sending areas. If the property had already been downzoned to park and recreation use, theoretically a property owner would not be able to transfer development rights from his or her property to a sending area because no future development rights remain on the property. However, this issue has not been challenged in Georgia courts.

Hard Armoring

Several types of armoring strategies exist. Private landowners and governments have attempted to control flooding and erosion in coastal areas through the use of soft armoring and hard-engineered armoring. Hard-engineered armoring of shorelines includes sea walls, revetments dikes, bulkheads (seawalls), tide gates and storm surge barriers (Grannis 2011). These structures may be built onshore or offshore, and are being employed less frequently in recent years because of the negative environmental impacts such hard armoring has on coastal ecosystems, especially wetland migration, and the increased the rate of erosion and flooding such structures have on neighboring properties. Furthermore, certain hard-engineered

structures may impede public access to public beaches in violation of state statutory law or the common law public trust doctrine. When deciding when to employ hard-armoring strategies, decision makers need to weigh the short-term and long-term environmental and economic benefits and costs of hard-armoring strategies. Decision makers "need to balance many trade-offs, such as the degree of threat to people and property, cost to build, value of the threatened property or infrastructure, long-term costs to maintain, environmental impacts, the physical conditions of the property (such as geology and elevation), aesthetics, and impacts to public access" (Grannis 2011).

Glynn County should consider requiring a hard-engineered structure permit before any hard armoring of the coastline may be initiated. Such permits can be conditioned on the appropriateness of the proposed hard-armored engineering on the property, and its potential impacts on the environment and neighboring property owners (Grannis 2011). By permitting the construction of hard-engineered structures, the County is better able to monitor the installation of such structures to ensure compliance with standards and document the kind of effects such structures have on the environment or nearby properties so that it can adjust its permit conditions accordingly, or flat out prohibit such hard armoring in the future if negative impacts outweigh positive benefits. Finally, the County could also create a permitting scheme for the removal of hard-engineered structures under certain circumstances, such as when the structure is causing severe erosion on nearby properties or is impeding public beach access (Grannis 2011). An alternative to a permitting scheme for the removal of hard-engineered structures would be a voluntary program whereby the County provides financial assistance in removing hard-engineered structures and replaces such structures with soft-engineered structures that fewer negative impacts on the environment and surrounding properties.

Soft Armoring

The soft armoring of coastlines has become a preferred alternative to hard armoring in many jurisdictions since soft armoring typically has fewer negative environmental impacts and is generally less expensive than hard armoring techniques. Generally speaking, soft armoring "creates man-made barriers that replenish or mimic natural buffers or elevate land so that structures are less vulnerable to flooding, storm surge, and erosion" (Grannis 2011, 39).

Examples of soft-engineered armoring include beach renourishment, revegetation, wetlands restoration, and living shorelines (Grannis 2011). Beach renourishment is a program where sand is placed on beaches "to increase the elevation and distance between upland areas and shoreline, which acts as a buffer to dissipate storm wave energy and block rising water

from inundating lower elevation areas" (NYC Planning Department 2013, 82). Though the sand may erode as waters rise or during intense storms, the sand can be replenished again afterward. Revegetation increases the viability of dunes and highly-erodable shoreline by "trapping and stabilizing sediment, as well as providing beach habitat" (NYC Planning Department 2013, 82). Finally, though the term "living shoreline" includes a number of innovative shoreline design strategies, the defining feature of "living shorelines" is the incorporation of ecological functions for shoreline stabilization (NYC Planning Department 2013). Living shorelines typically include some type of breakwater structure to create zones where water is calm enough to allow for vegetative growth (NYC Planning Department 2013). In many areas on the East Coast, living shorelines have replaced formally hard-armored shorelines to create a more "naturalized edge where space constraints do not allow for full restoration" (NYC Planning Department 2013, 78).

As in the hard armoring context, Glynn County could consider requiring a soft-armoring permit before any soft armoring of the coastline may be initiated. Such permits can be conditioned on the appropriateness of the proposed soft-armoring strategy on the property, its effectiveness to protect against or withstand SLR and other coastal hazards, and its potential impacts on the environment and neighboring property owners. Moreover, a permitting scheme allows the County to monitor the execution and effectiveness of soft armoring since such techniques are relatively new compared to the traditional hard-armoring techniques discussed above. Finally, the County should consider creating a voluntary program whereby the County provides financial assistance in removing hard-engineered structures and replacing such structures with soft-armoring structures, live a living shoreline, which have fewer negative impacts on the environment and surrounding properties. Though soft-armoring strategies may require more technical expertise and design, such strategies provide a more sustainable long-term strategy for protecting beaches from erosion and preserving natural ecological processes.

Conclusion

Overall, this paper is meant to help decision makers in Georgia identify the potential risks and vulnerabilities associated with SLR, and assess the range of adaptive strategies available to increase the resilience of coastal communities. Governments bear the primary responsibility for SLR preparedness since they have the duty to protect the health, safety, and welfare of the public, and have more tools at their disposal by which they can adequately protect the public from rising sea levels. This paper presented a number of adaptive strategies available to governmental actors to prepare for SLR, including (1) coastal overlay zones, (2) rolling easements, (3) rezoning/downzoning strategies (including amortization); (4) comprehensive plan amendments; (5) Georgia's Coastal Zone Management Act; (6) floodplain regulations; (7) land acquisition and conservation efforts; (8) TDR programs and (9) soft and hard armoring strategies.

Based on my analysis, I would recommend a series of steps for Glynn County. First, Glynn County should enact a coastal overlay zone for all coastal properties within the next five years. This would ensure that any new development in vulnerable coastal areas includes specific design standards meant to withstand flooding and encroaching waters. The coastal overlay would be less controversial than an outright rezoning or downzoning of coastal properties, though it may be less effective overall than a comprehensive rezoning. Next, the County should consider implementing a TDR program, and perhaps partner with Brunswick through intergovernmental contract in the implementation and execution of the program, to start shifting development rights and density toward less vulnerable and more urbanized areas. Implementing a TDR program after a coastal overlay has been enacted should still allow property owners to sell development rights in their coastal properties since underlying development potential (and thus economic value) still remains.

Once a TDR Program has been in place for some time, and property owners are given a reasonable opportunity to sell development rights in their properties, the County should implement a comprehensive rezoning/downzoning of vulnerable coastal properties. Since property owners in these vulnerable areas have been notified of impending SLR and provided an opportunity to sell development rights in their properties, the "takings" issue may be less of a concern and owners may be less likely to challenge the rezoning initiative since they knew such was coming for several years or decades, perhaps because of its inclusion in a comprehensive development plan, future land use map, or similar governmental publication. Soft shoreline armoring may also be a wise tactic for coastal areas that are heavily developed, such as St. Simons, since investments in these areas are significant and need additional time to prepare for SLR and recoup investment-backed expectations. A soft-armoring initiative should be funded in part by the State of Georgia since it has an interest in maintaining beaches for

public access and recreational use, and an interest in protecting the health, safety and welfare of its citizens. A soft armoring program should begin within the next decade.

Overall, governments can reduce coastal vulnerability and SLR impacts by proactively planning and preparing for rising seas.

Appendices

Appendix A: Bathtub Model

This paper used the bathtub model to determine whether a 1 meter rise in sea level would affect real property and physical infrastructure in Glynn County, Georgia. The "bathtub model" is normally used to approximate SLR based on the assumption of uniform water level rise at all levels of the land being examined. The bathtub model is useful to project uniform sea level rise by assuming inundation on all land below a specified elevation. The 1 meter rise in sea level scenario used in the following map projections was created by the Skidaway Institute of Oceanography to demonstrate the potential area of inundation with a 1 meter rise in the Mean Higher High Water (MHHW) surface on Georgia's coast. The one meter SLR values were generated based on a water level rise above the current Mean Higher High Water (MHHW) surface estimated for each coastal Georgia county using historical tidal gauge data. The author then used the "Clip" tool in the mapping program to clip out the SLR values for Glynn County specifically. Base elevation data used for the scenario is a 4ft by 4ft cell resolution liDAR derived hydro enforced digital elevation model (DEM) created by the Georgia Coastal Elevation Project. Areas of the DEM lower than the 1 meter SLR scenario surface were removed unless connected to tidal waters.

Appendix B: Zoning Categorizations used in the Analysis Section

Zoning Category	Categorization on Map
Basic Industrial (BI)	Industrial
Conservation Preservation (CP)	Conservation Preservation
Forest Agriculture (FA)	Forest/Ag
Freeway Commercial (FC)	Commercial
Government (G)	Government
General Commercial (GC)	Commercial
General Commercial Core (GC-Core)	Commercial
General Industrial (GI)	Industrial
General Residential	Low Residential
General Residential Core (GR-Core)	Low Residential
Highway Commercial (HC)	Commercial
High Residential (HR)	High Residential
Light Commercial (LC)	Commercial
Light Industrial (LI)	Industrial
Light Manufacturing (LM)	Industrial
One-Family Residential (M12)	Low Residential
One-Family Residential (M20)	Low Residential
One-Family Residential (M6)	Low Residential
Medical (MED)	Commercial
Mobile Home Park (MH)	Low Residential
One-Family Residential (Mh-20)	Low Residential
One-Family Residential (Mh-6)	Low Residential
One-Family Residential (Mh-9)	Low Residential
Medium Residential (MR)	Low Residential
Neighborhood Commercial (NC)	Commercial
Office Commercial (OC)	Commercial
Public (P)	Public
Planned Commercial (PC)	Commercial
Planned Development (PD)	High Residential
Planned Development General (PD-G)	High Residential
Planned Development-Traditional Neighborhood (PD-TN)	Low Residential
Planned Development (PD-H)	High Residential
Planned Development Residential (PD-R)	High Residential
One-Family Residential (R-12)	Low Residential
One-Family Residential (R-20)	Low Residential
One-Family Residential (R-6)	Low Residential
One-Family Residential (R-9)	Low Residential
Residential Estates (RE)	Low Residential
Resort Residential (RR)	High Residential
Village Mixed Use (VMU)	Commercial
Village Residential (VR)	Low Residential

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